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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN, THE NATIONAL IRONFOUNDING EMPLOYERS' FEDERATION, THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

JANUARY 9.

Institute of Marine Engineers:—Meeting in London at 6 p.m. "Modern Steels for Marine Engineering," Paper by T. H. Burnham.

Institute of Metals (North-East Coast Local Section):—Meeting at Armstrong College, Newcastle, at 7.30 p.m. "Welding," Paper by a representative of Messrs. Metropolitan-Vickers Electrical Company, Limited.

JANUARY 11.

Institute of Metals (London Local Section):—Meeting at 83, Pall Mall, London, at 7.30 p.m. "Beryllium and its Alloys," Paper by H. A. Sloman.

JANUARY 12.

Institute of Metals (Sheffield Local Section):—Meeting at the University, Sheffield, at 7.30 p.m. "Protection from Corrosion of Aluminium and its Alloys," Paper by N. D. Pullen.

Institute of British Foundrymen.

JANUARY 9.

Lancashire Branch (Burnley Section):—Meeting at 7.15 p.m. "Blast-Furnace Practice and Notes on the Making of Irons." (Lecturer to be announced later.)

JANUARY 10.

London Branch:—Meeting at Charing Cross Hotel, London, at 8 p.m. Joint meeting with the Electro Depositors' Technical Society.

Lancashire Branch (Preston Section):—Meeting at 7.30 p.m. "Mechanisation in the Foundry," Paper by G. E. France. (Illustrated by cinematograph film.)

JANUARY 12.

Middlesbrough Branch:—Meeting at the Technical Institute, Middlesbrough, at 7.45 p.m. "A General Review of the Foundry Trade To-day," Paper by Major R. Miles.

JANUARY 13.

Lancashire Branch (Burnley Section):—Annual social.

West Riding of Yorkshire Branch:—Annual dinner.

Scottish Branch:—Meeting in Glasgow, at 4 p.m. "Moulding and Casting Hydraulic Valves," Paper by R. D. Lawrie.

Theory and Practice.

We are all familiar with the man who draws a sharp dividing line between "theory" and "practice," who, with thumbs in his waistcoat armholes, proudly declaims to an admiring audience of fellow workmen that "so-and-so may be all right in theory, but it won't work out in practice." He is usually extremely anxious to get on with the job, leaving the thinker, whether engineer, metallurgist or chemist, to his futile brain-racking. Almost as well known is the confirmed, if rather more enlightened, practical man who talks about applying theory to practice. Now these two poor innocent fellows, separating what they are pleased to call theory and practice into hermetically-sealed compartments, are blissfully unaware of the facts that without practice there would be no theory, that theory is merely a way of looking at certain things which are observed to happen in practice, and that without some conscious or unconscious theory they would be utterly and entirely lost and helpless in the practice of their particular branch of technology.

The theorist is generally a man whose motive for thought is the desire to appreciate more clearly the rules according to which phenomena occur, whose curiosity is aroused and made active by his intellectual difficulties in reflecting upon common knowledge. This speculative activity may be found equally well in manager, foreman, workman or technical expert, although in fairness to the last-named it must be admitted that the probability of possessing it is much greater in his case. A sound theory comprises little more in essentials than the imaginative consideration of the principle involved, followed by the substitution of laws based upon evidence for fairy tales embodying a measure of wish-fulfilment. In any particular branch of science or technology the wealth of detail is infinitely too great to permit the subject to be attacked without some logical basis or train of thought to act as a guide to the interpretation of the details. As Earl Russell once remarked, the man who says that unsupported bodies in air fall has merely generalised, and is liable to be refuted by butterflies, balloons and aeroplanes, whereas the man who understands the theory of falling bodies knows also why certain exceptional bodies do not fall. A comprehensive theory replaces a welter of disconnected and fragmentary facts by a co-ordinated, orderly arrangement, a consistent explanation giving life and motion to isolated thoughts.

How often does it transpire that the good craftsman or foreman, a self-styled "practical man," is himself an unconscious theorist, whose theories require merely a little better expression or revision in the light of modern scientific ideas to become a really sound interpretation of the phenomena underlying his particular field of technical activity. There can, in fact, be no separation of theory and practice; every observation made in practice first acquires its meaning for technical science by virtue of the significance which a theory imparts to it, and the two are so inextricably bound up with each other that to decry the one to the advantage of the other is merely to deny all technological progress.

Sand Control.

We little thought, some fifteen years ago, that sand control would pass from the hand of foundryman to the laboratory. We remember at that time every foreman would possess such formulæ as 4 parts of Red Mansfield, 4 parts of silver sand, 2 parts of Barrow dull red, 5 parts of G.R. yellow and 8 of old sand; this particular mixture was favoured for use when making steel castings in green sand. Our only

criticism of it is that it has insufficient ingredients, as the more types of sand used, the less chance of variations making any profound difference.

Mr. Hudson's Paper, concluded in our columns this week, shows very clearly that sand control is a paying proposition, but withal the major factor is cleanliness, especially in regard to freedom from tramp iron and silt. There is a remarkable number of methods now available for the preparation and distribution of sand. It is becoming more and more apparent that, with the exception of the large jobbing foundries, the sand floor, associated with foundries for so many generations, is becoming a thing of the past. Even for non-ferrous foundries there is a tendency to carry the sand up to a platform above the moulding stations and there, perhaps by hand-barrows, fill up hoppers placed conveniently for operating by moulders working either with machines or on a bench.

Control of the properties of the sand used indirectly controls the skin and the soundness of the castings made. One of the most important factors that has come to light is the possibility of controlling mould density as rammed, because a start is made with a *standardised raw material*. It is no fairy story to postulate that no matter how excellent the results obtained when using uncontrolled, uncleaned sand, still better castings will be furnished immediately standardised sand has established itself as giving initially the equivalent grade. It must not be thought that the mere installation of modern plant will achieve this desirable end, although deterioration in the quality of the sand is unthinkable. But if modern plant is associated with adequate laboratory control, it will earn dividends, give a better return to pieceworkers and eliminate yet another of the all too many variations in foundry practice. It is pleasing to note that the plant now installed in the laboratories of Sheffield University is capable of yielding a standardised sand, and now only a few modern controllable moulding machines are required to enable standardised moulds to be made to indicate really worth-while experiments on the influence of temperature in making castings.

Publication Received.

Foreign Exchange Restrictions.—Published by the Swiss Bank Corporation, 99, Gresham Street, London, E.C.2.

This 57-page booklet tells in concise language exactly what restrictions are imposed by 111 countries, and indicates in no uncertain manner why international trade is not picking up at the same rate as domestic business. It always strikes us as deplorable that the World Economic Conference was such a dismal failure, as logically examined all these various nations are indulging in a sort of cormorant-like practice of biting off their noses to spite their faces. To those uninitiated into finance, like the reviewer, it appears that most of these countries restrict exchange because a free market would land them in a sort of international bankruptcy court, devoid of the power of appointing an experienced receiver, capable of managing the assets to the advantage of all interested parties. Apparently, though diplomatists would use other language, this is exactly what has happened in Newfoundland.

An offer is made by the publishers to give a more detailed explanation of the devices used by the various countries in effecting their restrictions.

The monthly bulletin of statistics published by the economic intelligence service of the League of Nations shows that in October, 1933, there was a further increase in the total value of international trade of 8.3 per cent. for imports, and 16.3 per cent. for exports, compared with April, 1933, and 4.7 per cent. and 2.1 per cent. respectively compared with September.

Bell-Founding in Ireland.

By G. I. Vann.

Shandon's Bells, in the City of Cork, are probably Ireland's best-known bells It was revealed a few days ago at a meeting of the Cork County Committee of the Irish Tourist Association that the Fox Film Corporation wished to record the notes of these beautifully-toned bells on a sound film, which would most likely be distributed all over the world.

But, of course, there arose a snag; the folk responsible for giving permission insisted on a fee of three pounds before they would allow the bells to be rung, and the film people refused to pay, so the bells of Shandon will not be heard apart from "the pleasant waters of the River Lee."

When Ireland was an island of saints, the bell-founding industry flourished. The monks made the bells then, but as time went on it became the privilege of the business man to supply the demand.

About one hundred years ago Dublin was celebrated for the quality and tone of its bells, and to-day, although there is now only one bell foundry in the Irish Free State, Irish-made bells can be seen in each of the five continents.

The existing foundry, which is now run under the name of Matthew O'Byrne, is situated in James' Street, Dublin. In this old-world part of Dublin quite a prosperous business is carried on. Peals of bells, single church bells, and a multitude of other kinds of bells are produced in up-to-date methods and modern tuning, and other machinery helps to turn out an amazing number of what would appear to be an almost unsaleable commodity.

In the olden times, owing to the difficulties of transporting heavy bells over the tracks which served as roads, the bell founders travelled to the place where the bell was to be hung and there it was cast. Probably something of the same principle prevails at the present time, accounting for the fact that nearly all the bells required for Irish churches are cast in Dublin, including the bell in the pro-cathedral in Dublin.

Ireland's first bell founder was Saint Asicus, who was described as "Priest and Bell-founder." He was consecrated the first bishop of Connacht by Saint Patrick in A.D. 448, and is the first Christian bell founder of whom there is an authentic record. It is believed that Saint Asicus was the maker of the famous Saint Patrick's bell which was rung at the Eucharistic Congress in Dublin in 1932. This bell is a plain hand bell of quadrangular form with rounded corners, and is composed of two pieces of sheet iron riveted together. Over this is a coating of an alloy resembling brass, which has withstood the wear and tear of the centuries remarkably well, and is a great example for the founders of the present day.

Busy Foundries at Bo'ness.—Signs are now evident of the ten years' trade depression lifting in Bo'ness, and already 1934 is assured of much better trade returns than the previous year. The boom in the textile trade in the West of Scotland has given a fillip to the trade of the ironfounders in the district, and one foundry reports that within the past three or four months their sales have been doubled, and they are now passing through a period of prosperity equal to that of ten years ago. Soon after the tax on foreign carpets was levied, home manufacturers found that they were unable to cope with the rush of orders, and, grasping the situation, they set about extending their factories, installing new machinery and generally bringing their plant up-to-date. For one loom alone castings numbering between 1,000 and 2,000 are required, and orders for hundreds of thousands of these pieces have lately been placed with Messrs. A. Ballantine & Sons, New Grange Foundry, Bo'ness, who state that prospects for the coming year are very bright. In the rain water and soil goods department there has been a great increase in trade. Bo'ness Iron Company reports that increased building programmes in England have considerably increased the demand for light castings.

Random Shots.

"The bears are dead, long live the bulls!" Conferences, pacts, agreements and talks about stabilisation of currencies all fade into insignificance before the great fact that in the public mind confidence is taking the place of pessimism. These post-war years have been a time of disillusionment and disaster for investors in all kinds of securities, and the climax has come in the form of fading currencies. This final blow, however, is likely to prove our salvation, for investors are rushing pell-mell to to put their money into solids.

* * *

Cotton, rubber, wheat and metals have always been gambling counters for people who dreamt of riches without working for them, and fortunes have been made—and lost—by dealing in futures. The past few months have seen a tremendous "come back" in metals on the part of the public, and from a state of stagnation, which threatened to close the doors of the Metal Exchange, we have passed to pulsing activity, with the weekly turnovers in the base metals amounting frequently to nearly 30,000 tons. Tin has staged one of the most remarkable rises ever achieved by this metal, notorious as it is for sensational price movements. Copper has come into favour too.

* * *

Gambling is not child's play, and the speculator in metals wants plenty of nerve and pluck. Remember that London is the cockpit of the metal trade, and to that unpretentious building in Whittington Avenue come buying and selling orders from all over the world, while the course of markets is subject to every influence political, commercial and social. Then there is the exchange factor, which recently has appeared to be operating in a manner contrary to all economic laws.

* * *

The time allotted for the daily dealings in metals is very brief. At a few minutes to twelve the "ring"—just a wooden bench set in a circle—fills up with brokers, and standing behind them are "authorised clerks" and other members intent upon the opening "ring" of the day, copper. On the stroke of the hour the secretary from his rostrum calls out "Copper, gentlemen," and if the market is active pandemonium breaks loose for ten hectic minutes. Bids, offers and counter bids are flung across the ring with lightning rapidity, and the clerks are hard put to it to keep pace in their notebooks with all the deals recorded. At 12.10 a bell rings above the babel, and all dealing in copper must instantly give place to ten equally exciting minutes in tin. By 1.20 the midday session is over, and after the official closing prices have been read out amidst an expectant hush, members disperse to despatch cables and secure a much-needed lunch.

* * *

This is the atmosphere surrounding trading in metal futures, and the speculator who gives his modest order to buy or sell a three months' warrant must realise that his venture is but a cork tossed upon the waters of a seething sea of ramps and raids. It may float or it may sink, swallowed up by the waves of some temporary bear drive. If you must gamble, don't grumble if the luck goes against you!

Marksman.

The Properties and Testing of Foundry Sands.

The following article is a lengthy abstract from a circular letter issued by the American Bureau of Standards which details the exact position of sand testing in the United States of America.

Introduction.

The use of sands and other materials as a means for putting metals into useful forms by castings is known to date from the time of the earliest written records and, with a high degree of certainty, can be projected back far into prehistoric times. Although casting is one of the oldest of all metallurgical operations, it has been until very recently one of the most conservative and has been guided largely by tradition and custom. As an example, it is only within the past two decades that a systematic investigative study has been made of the essential and characteristic properties of foundry sands.

The greater precision now required in foundry work, resulting in large measure from competition with other processes, has necessitated careful study and control of the various factors which influence the production of good metal castings. The mould into which the metal is poured and the sand out of which the mould is formed rank foremost among these factors. A suitable and satisfactory mould is a prime requisite in all successful foundry operations. No substitute for it exists.

The (American) Bureau of Standards receives many inquiries relating to new sand deposits, the reclamation of used sands, as well as the technique necessary for developing the best properties for foundry use of any particular grade of sand. The immediate aim of these notes is to furnish information on the characteristic properties of typical commercial foundry sands as determined by approved test methods. Much of the best available information on the properties and testing of foundry sands has resulted directly from the extensive research sponsored by the American Foundrymen's Association and much of the information presented herewith has been obtained in the Bureau's co-operative studies carried out with that organisation.

Most of the results used later to illustrate the characteristics of foundry sands have been taken from tests of representative commercial sands which have been carried out as part of this Bureau's work. The use of these data is not to be considered in any way as an endorsement of the particular sands. There are numerous other sands with nearly identical properties that might be mentioned.

General Properties of Moulding Sands.

A brief account of the general principles involved in the use of sand moulds will be worth while. A casting is ordinarily made by pouring the molten metal into a mould which consists essentially of a cavity of suitable shape and size in a quantity of sand. The sand in such a mould may be either moist or dry or only the sand which forms the surface walls of the cavity may be dry. By far the greater amount of sand used in the foundry is used in the moist, or green, condition. The moulding qualities of a sand and its other characteristic properties are determined on the sand in this condition. For this reason, most of the discussion presented deals with the green sand.

The term "sand" is used in various ways, usually in a qualified sense, for example, glass sand, to indicate a specific usage. In the foundry, the term is restricted to sand consisting entirely of grains of silica. A natural moulding sand consists essentially of the grain material, made up of grains of silica, and the bonding material, which is largely clay. In addition, there may be small amounts of other substances the character of which depends upon the nature of the rock from which the sand originated. These substances, usually undesirable, are sometimes referred to as the "fluxing ingredients."

The essential characteristics which any moulding sand must possess are apparent to anyone who observes the making of a mould and its use in the casting of a metal. Naturally, the sand must possess mouldability when wet, or when "tempered," with a suitable amount of water. The strength or cohesiveness of the tempered sand after being compressed or rammed is surprising. The need for considerable strength becomes apparent, however, as one further observes. The forming of an impression, accurate in all details, of a pattern and removing the pattern from the sand which has been rammed about it is only a small part of the story. The strength of the compacted sand must be sufficient to ensure freedom from crumbling of the sand from any part of the walls of the mould, especially from that portion which lies in the cope, that part which, when the entire mould is assembled, is inverted and forms the upper part of the mould cavity. Strength is also required for holding firmly in place the cores which are placed in the mould cavity and around which the molten metal solidifies to form cavities and openings in the finished casting. Strength in the sand is especially necessary to withstand the erosive and cutting action of the molten metal as it is poured into the mould as well as to withstand the pressure of the metal itself within the mould.

Although the moulder always makes special provision for the "venting" of a mould for the escape of air and other gases during pouring, it is evident, even to a casual observer, that the sand itself must play an important part in the venting of the mould during and subsequent to pouring. Copious amounts of air and steam escape from the surface of the sand. The property of the sand which permits this to occur is termed "permeability," and, while this is related to the porosity of the sand, the two are not synonymous.

Occasionally one sees in a foundry castings which, when taken from the mould, are heavily encrusted with burned-on sand. The removal of this is tedious and often difficult, and the surface of the underlying metal is often rough and unsightly, and details of the pattern are not accurately reproduced. In such cases it is evident that the sand, as a whole, was not sufficiently infusible to withstand the heat of casting. This infusibility is a property of moulding sand to which much importance is attached. It is related to certain constituents, especially the fluxing constituents, and not to the grain of the sand.

Whilst the characteristics described cover the salient features of good moulding sands, the list is by no means complete. It is evident, however, from the discussion that moulding sand is a more or less specialised product, the selection and preparation of which should be carefully supervised and controlled. The testing methods by which this can readily and accurately be done form much of the subject-matter of this circular.

The Determination of the Properties of Moulding Sands.

Preparation of Sands for Study.—As in all testing work, *representative* samples must always be selected. The Committee on Moulding Sand Research of the American Foundrymen's Association has made definite recommendations for suitable methods for the sampling of sands, in order that representative samples may be obtained.

Most of the tests are made on moist (tempered) sand. It is necessary, therefore, that there should be a specific method for tempering. The method used by the Bureau is as follows:

A sample of the sand, sufficient in amount for all of the tests, should be dried in an oven at a temperature between 105 and 110 deg. C. for at least one hour. The sample of sand is allowed to cool and then tempered with water. It is usually desirable to temper different portions of the dried sand with different amounts of water; three are generally used, the smallest amount being chosen so as to leave the sand a little too "dry." The amounts used for the other portions are increased progressively, and one must be guided largely by experience in their choice. Thorough mixing and uniform distribution of the water throughout the sand are necessary. The sand, after tempering, should be kept in an airtight container (for example, a glass quart jar with screw top and rubber seal) for 24 hrs. before being used for testing purposes.

Determination of Moisture.—The water content of the tempered sand should be determined before further tests are carried out. This is done by drying a weighed sample (100 grs.) on a watch-glass or other open dish in the same manner as the original drying of the sand. The dried sample is allowed to cool in a desiccator or covered vessel and then re-weighed. The loss, of course, is numerically equal to the percentage of water contained in the tempered sand.

The amount of water used in tempering most commercial moulding sands for testing purposes lies between 3 and 9 per cent. (approximately).

A rapid method for determining the water content of a sand is often very desirable. A method by which satisfactory results have been obtained at this Bureau consists in mixing 50 mls. of alcohol with 100 grs. of the tempered sand in a wide evaporating dish, igniting the alcohol and allowing it to burn until the flame is extinguished. Continuous stirring of the sand during the burning is advisable. The difference between the weight of the sample after cooling and the initial weight gives the water content in per cent. and agrees well with the value obtained by drying in the oven, as is shown by the following results (Table I):—

TABLE I.—*Water Content of Tempered Sand obtained by Two Methods.*

Sand.	Water content.	
	Oven drying.	Ignition with alcohol.
	Per cent.	Per cent.
Albany 00	5.3	5.6
Downer	4.7	4.7
Pettinos	5.9	5.8
Steel foundry	7.5	7.5

Fineness.—The determination of the fineness of a moulding sand is undoubtedly the most important single test which is made on a sand. Although fineness is a measure only of the relative size of the constituent particles of the sand, the information gained by a test of this kind is much broader than the name would suggest, and much can be inferred from the results as to the other important characteristics of the sand, *viz.*, permeability, strength, surface finish of castings, etc.

The method is essentially one of "mechanical analysis," and consists usually of a combination of flotation and sieving. By means of flotation, particles whose diameter is approximately less than 20 microns (1 micron (μ) = 0.001 mm.) are separated from those having a greater diameter. The fine-grained portion consists largely of the bonding clay of the sand, as well as some other very fine material, and is designated by the name "clay substance." The coarser material, consisting essentially of the silica, is termed the "grain." By means of sieving, the relative amounts of the predominating grain sizes or "texture" of the grain material is determined after drying.

Since the bonding power of a moulding sand is directly related to, and the permeability may also be affected by, the clay content, the determination of the clay substance is of very considerable importance. The quantity of clay substance may be determined in various ways, most

of which depend upon the difference in rate of the settling of particles of different sizes when suspended in water.

The test is carried out on a 50-gr. sample of the dried sand. The separation of the fine clay particles from the remainder of the material is expedited if the water used for the suspension contains a small amount of sodium hydroxide, which assists in deflocculating the clay. The common approved practice is to use 25 mls. of a 1 per cent. aqueous solution of sodium hydroxide diluted with distilled water to 500 mls. The sand and water are placed in a glass container, which should be securely closed. A quart glass jar, such as is in common use in the household, is generally used. It is necessary to agitate the sand-water suspension very thoroughly so as to separate the clay completely from the sand grains. A simple device utilises a small electric stirrer, such as is used for preparing soft drinks. Five minutes' stirring with this device has been found ample in most cases. A motor-driven device for repeatedly turning the jar upside down is also used, and has been recommended by the American Foundrymen's Association. The process is continued for 1 hr. at a rate of 60 reversals of the bottle per min.

In order that different workers may obtain comparable results, it is necessary that a definite method of separation of the suspended clay from the coarser particles be carefully followed. After stirring the sand-water mixture, the top of the container is removed, adhering particles washed into the jar, and the jar filled with distilled water to a reference mark near the top, allowed to stand for 10 min. and the water, with the suspended clay, is removed by siphoning until the level has been lowered 5 in. below the initial level. The siphon is then removed, the jar filled with distilled water, and the water agitated sufficiently to bring the grain into suspension. The jar and contents are then allowed to stand for 10 min. and the siphoning repeated. The operation is repeated again and again, with a settling period of 5 min., however, instead of 10 min., until the supernatant water becomes entirely clear after standing for 5 min. By this means all particles which settle at a rate of less than 1 in. per min. are separated from the remainder. The finer particles removed by siphoning constitute the "clay substance." The remainder is the "grain." This is removed from the jar, filtered, dried and weighed. The difference between the two weights of the sample represents the clay substance; no attempt is made to recover the clay which is carried off by the water in siphoning.

The bonding power of moulding sand decreases with use. This decrease is caused primarily by the driving off of the chemically-combined water. The bond is practically destroyed in "burnt" sand. The need for the treatment and systematic "control" of sands within the foundry is thus apparent.

The grain remaining, after the clay substance has been removed, is dried and the distribution of grain sizes is determined by sieving. The sieves (shown in Table II) selected from the Bureau of Standards series are used for this purpose.

The sieves, which are 8 in. in dia. and of the half-height construction, are nested securely together in order with the coarsest at the top and a pan beneath the finest (No. 270). The sample is placed on the upper sieve and covered, and the whole assembly shaken by means of a Rotap mechanical sieve shaker or its equivalent for a period of 15 min. The amount remaining on each sieve is weighed and its percentage of the sample calculated. The approximate grain size of any of the various fractions secured in this manner is assumed to be that of the size of the openings of the sieve immediately preceding the one on which the sample was retained.

The arbitrary value of 3 has been assigned by the Committee on Moulding Sand Research, American Foundrymen's Association, to material which fails to pass through the first sieve (No. 6) and 300 to the particles which pass the finest sieve and are caught on the pan. Two further arbitrary changes have been made in that the number 5 has been assigned to those

Table II.—*Sieves Selected from the Bureau of Standards Series for Foundry Use.*

Sieve No.	Opening. In.	Opening. Mm.
6	0.1320	3.360
12	0.0661	1.680
20	0.0331	0.840
30	0.0232	0.590
40	0.0165	0.420
50	0.0117	0.297
70	0.0083	0.210
100	0.0059	0.149
140	0.0041	0.105
200	0.0029	0.074
270	0.0021	0.053

grains which pass sieve No. 6 and remain on sieve No. 12 and 10 to those grains which pass sieve No. 12 and remain on sieve No. 20.

For purposes of classification and specification, an average grain-fineness number is often advantageous. This is readily obtained as is shown in Table III, the calculation being analogous to the method used for determining the centre of mass of a system of rigidly-connected bodies. The average grain-fineness number is then

Table III.—*Calculation of Grain Fineness Number of a Foundry Sand (Downer Moulding Sand).*

Sieve No.	Amount (A) retained on sieve.	Relative (*a*) grain size (S).	Product, AS.
	per cent.		
6	0.0	3	0
12	0.0	5	0
20	0.8	10	8
30	1.2	20	24
40	3.4	30	102
50	4.4	40	176
70	29.6	50	1,480
100	32.2	70	2,254
140	12.2	100	1,220
200	1.5	140	210
270	0.4	200	80
Pan	1.3	300	390
Total (ΣA) =	87	Total (ΣAS) =	5,914

Average grain fineness number

$$\Sigma AS \div \Sigma A = 5{,}914 \div 87 = 67$$

(*a*) Proportional to the reciprocal of the grain diameter

approximately proportional to the total surface area of the particles of a unit weight of the material.

The results show the relation of the average fineness number to the distribution of grain sizes of the sand.

Efforts have been made to represent grain-size distribution numerically in a manner similar to average grain fineness. If the complete results of the mechanical analysis by sieving are available, a numerical "distribution factor" is, of course, not needed. A method which is mathe-

Table IV.—*Pouring Temperatures for Foundry Castings (approximate). (The pouring temperature is varied with size of casting and other factors.)*

Castings.	Pouring temperature. Deg. C.
Aluminium alloys	700— 780
Brass	1,000—1,320
Cast iron (stoveplate)	1,260—1,425
Malleable cast iron	1,425—1,550
Steel	1,525—1,600

matically sound consists in an extension of that used in Table IV.

Instead of the summation of the products, AS, the summation of the products, AS^2 is divided by the mass (ΣA), that is, the total percentage of grain. A much simpler method consists essentially in designating the number of consecutive sieves which retain at least 75 per cent. of the material. In case of lack of complete results of sieving, such a factor, together with the average fineness number, would serve to define a sand, closely enough for practical use.

Strength.

Compressive Strength. — It was pointed out that "strength" is one of the important characteristics of moulding sand. In a strict sense, the term, strength, should be restricted to the moulded sand specimen and not to the loose sand. Of the various methods in use, the one which determines the strength of the moulded specimen in compression is preferred and used most frequently at this Bureau. The specimen consists of sand which has been tempered in the manner described, compacted in a known and reproducible manner, into a cylinder, 2 in. in dia. and 2 in. in height (tolerance $\pm$ $\frac{1}{16}$ in. in height).

The sand is compacted by ramming within a cylindrical tubular container, by means of a freely sliding (falling) weight (17.5 lbs.), so arranged that the entire cross-section of the cylinder is uniformly affected. Three blows, under a 2-in. drop of the weight, are used. If the height of the rammed specimen does not come within the prescribed limits a new specimen is made with a slightly different initial amount of sand.

The device for determining the compressive strength is of relatively simple construction, the calibrated spring being the most important feature. By turning the handle and compressing the spring, load is applied through the movable compression head to the sand specimen at a rate of from 20 to 40 lbs. per min. until the specimen collapses. The distance through which the spring has been compressed at the time the specimen broke is shown by a calibrated rod which remains fixed in position. From the calibrated rod the pressure required to break the specimen may be read in lbs. per sq. in.

Various other means for measuring the compressive strength of sands have been devised and are to some extent used. In all of them specimens of the above form are used. For any particular moulding sand, the strength is dependent upon the amount of water contained and the compactness of the sand. For specimens prepared by ramming in the manner described, the water content is the principal controlling factor.

Other Tests.

The American Foundrymen's Association, through its Committee on Moulding Sand Research, has approved the compression test in all cases, as in disputes, in which comparisons of the results of different investigators are necessary. The determination of the tensile and the shearing strength, in place of the compression strength, is in rather wide usage. A method, formerly widely used, consists essentially in slowly sliding a straight bar of uniform rectangular cross-section moulded from the sand over the edge of a supporting table so that the one end overhangs. The weight of the maximum overhanging portion is determined. On account of the difficulty of producing specimen bars of uniform and reproducible properties, the use of this method is decreasing.

Since the strength of a moulding sand is primarily dependent upon the bonding material, any test which gives information on the nature and amount of this bonding material should be of interest. Much of the bonding substance is colloidal clay. Like colloids of this type, it has the property of adsorbing the colouring matter from dye solutions. Hence, the comparison of the colour of two glass tubes, one of which contains a water solution of a dye (crystal violet) and the other the same amount of a similar solution which has been shaken up with a sample of the dried moulding sand, will give some information on the colloidal character of the "bond" of the sand. The colour of the dye solution which

has been shaken up with the sand is diminished, the degree of diminution (measured by comparison with the unchanged dye solution of similar concentration) gives qualitative information on the bonding characteristics of the clay. In carrying out the test, it is advisable to add a small amount of an electrolyte (for example, acetic acid) to accelerate the settling of the colloidal substance and obtain a clear solution. Considerable experience, however, in the use and testing of moulding sands is necessary in applying the information. The test is unreliable for used sands, especially if they have been treated by the addition of various substances as is common practice in certain lines of foundry work.

Permeability.

A measure of the relative permeability of a chosen sand is obtained by measuring the rate of flow of air under pressure through a standard specimen. The specimen is identical with that prepared for the determination of compressive strength, with the important exception, however, that it is not removed from the container in which it is rammed. In routine testing, the determinations of compressive strength and permeability are made on the same specimen, permeability being determined first. The time required for forcing 2,000 cm³. of air through the standard specimen under a known pressure is measured with a stop watch. From the data obtained is calculated the volume of air passing through a unit volume of sand (a cube, 1 cm. on each edge) in 1 min. under a pressure of 1 gr. per cm². This is, by definition, the permeability of the sand and may be expressed by the formula:—

$$P = \frac{v.h}{p.a.t}$$

in which P = the permeability "number,"
v = volume (cm³.) of gas (air) forced through the specimen,
h = height of sand specimen (cm.),
a = cross-sectional area of sand specimen exposed to the gas (cm².),
p = pressure used in forcing the air through the sand (g),
t = time (minutes).

By substituting the values for v, h and a in the formula (2,000 cm³., 5.08 cm. and 20.27 cm²., respectively), the formula reduces to

$$P = \frac{501.2}{p.t}$$

The pressure is read directly by means of a manometer.

A diagram showing the essentials of the apparatus is given in Fig. 1.

The determination of permeability can be greatly expedited, for routine testing work, by a relatively simple modification of the apparatus, and with only slight sacrifice in accuracy. The modification consists essentially in controlling the rate of flow of air from the reservoir to the sand specimen by inserting in the supply tube a plug having an orifice of known diameter and shape. To ensure permanence against corrosion and other possible deterioration, gold is used as the material surrounding the orifice. In this modified method, it is necessary only to read the pressure at which the air is being forced through the sand and obtain the corresponding permeability number from a table based upon previous determinations.

Various precautions, depending upon the condition of the sand tested, are sometimes necessary in the determination of the permeability number. For example, a screen (60 mesh) is used to support specimens of dry sand containing little or no bonding material. In determining the permeability of baked specimens of a sand containing bonding material, a special holder is used and it is necessary to "seal" in the specimen with mercury and a rubber gasket to prevent the flow of air between the specimen and the adjacent wall of the container.

Permeability and strength of moulding sands are, in general, opposing properties. Conditions such as an abundance of bonding clay or a high degree of compactness, both of which are favourable to high strength, are conducive to low permeability numbers. The effect of progressive ramming is to increase the compressive strength of moulding sand and simultaneously decrease the permeability. The general effect of water content (degree of tempering) on the strength and permeability is shown, as well as the rather wide differences which may exist between different sands on account of the differences in their inherent characteristics, clay content, grain sizes, etc. The need for strictly defining the conditions of preparation of the specimens upon which strength and permeability are to be determined is apparent.

TABLE V.—*A.F.A. Classification of Sands according to Grain Fineness.*

Class designation.	Range in grain fineness number.*
1	200 to 300 (incl.)
2	140 „ 200
3	100 „ 140
4	70 „ 100
5	50 „ 70
6	40 „ 50
7	30 „ 40
8	20 „ 30
9	15 „ 20
10	10 „ 15

* In all cases, except No. 1, the range of fineness numbers extends up *to* but does not include the number marking the upper limit.

TABLE VI.—*A.F.A. Classification of Moulding Sands on the Basis of Clay Content.*

Clay designation.	Clay content.
	Per cent.*
A	0 to 0.5
B	0.5 „ 2
C	2 „ 5
D	5 „ 10
E	10 „ 15
F	15 „ 20
G	20 „ 30
H	30 „ 45
I	45 „ 60
J	60 „ 100

* In all cases, the range of percentage of clay extends *to* but does not include the upper limit.

Sintering.

Although silica, the chief constituent of moulding sand, undergoes two crystalline transformations on heating (870 deg. C. to tridymite and 1,470 deg. C. to cristobalite), it is otherwise stable until the melting point, 1,710 deg. C. ± 10, is reached. This temperature is well above the temperatures reached in the casting of iron and non-ferrous alloys. The nearest approach is in the making of steel castings. A casting steel becomes completely molten on heating to approximately 1,500 deg. C.

The refractoriness of a moulding sand under conditions obtaining in the casting of metals is dependent primarily upon the amount and nature of "fluxing constituents" and to some extent the bonding material. A determination of the melting temperature is seldom necessary. However, the determination of the temperature at which a sand sinters or "burns on" a casting is important. The method used for this determination consists in holding a ribbon of platinum, maintained at a chosen temperature by passing an electric current through it, against the surface of a specimen of the sand. The specimen is prepared in the manner already described for the determination of strength and permeability. After removal from the cylinder in which it was rammed, enough sand is cut away to reduce the dimensions to 2 in. by 2 in. by 1 in. and the specimen is dried for 1 hr., at 105-110 deg. C. The current is adjusted so as to produce the chosen temperature, as determined by an active pyrometer of the "disappearing-filament" type, proper corrections for emissivity and other conditions being made. The ribbon is then held for four minutes against the narrow face of the specimen by the weight (170 grs.) of the ribbon holder, and then examined after the current has been cut off for evidence of sintered sand particles sticking to it. The operation is repeated, each time at a temperature 25 deg. higher than the preceding one and on another portion of the specimen, until particles of the sand may be seen to have sintered to the ribbon. The temperature at which this occurs is taken as the "sintering point" of the sand. There is a fairly consistent relationship between the average grain size and the sintering temperature. This is definitely lower for sands of finer grain size than for those of coarser grain size.

The approximate pouring temperatures in ordinary foundry work are given in Table IV.

Miscellaneous.

Hardness of Mould Surfaces.—The determination of the surface hardness of green-sand moulds is a test which is coming into favour. The results, however, are more characteristic of the *mould* and particularly the compactness of the sand produced by ramming than of an inherent property of the sand. The test is somewhat analogous to that of the Brinell hardness testing of metals. A small portable device having a flat base, through which projects the hemispherical end (indentor) of a movable plunger acting against a spring, is pressed against a flat surface of the mould or sand specimen until there is close contact. The depth to which the indentor penetrates the sand is

TABLE VII.—*Sands for Specific Uses.*

Casting. Material.	Rel. size.	A.F.A. sand class.	Compressive strength.	Permeability number.
			lbs. per sq. in.	
Brass	Light	1; D or E	3—4.5	8—12
„	Medium	2; E	3—5	10—17
„	Heavy	3; E	3.5—6	17—25
Aluminium alloys	Light	1; E, F or G	3—7	8—15
„ „	Medium	1 or 2; E or F	4—8	10—20
„ „	Heavy			
Cast iron	Light	2, 3 or 4; E	3— 8	15—65
„	Medium	4 or 5; E	4— 9	65—100
„	Heavy	5, 6 or 7; E or F	6—10	75—150
Malleable iron	Light	3; E or F	3— 8	20— 50
„ „	Medium	4; E	4— 9	50—100
„ „	Heavy	5, 6 or 7; E	6—10	90—125
Steel	Light	5; C	4—8	100—150
„	Medium	5 or 6; C	4—8	125—200
„	Heavy	6 or 7; C	4—8	150—250

shown on a graduated scale. The inverse of the depth of penetration has been accepted as a measure of the hardness of the sand-mould surface; a penetration of 0 corresponds to a hardness number of 100 and *vice versa*. To the experienced moulder the results are indicative of the strength and permeability of the mould, particularly the surface layer.

Core Sands.—In general, considerably greater strength is required in sand cores than in sand moulds. In order to obtain the greater bonding strength various artificial "binders" are added to the sand. Silica sand is usually used, although moulding sand is used sometimes. The moulded core is usually baked in order to develop the required strength. The permeability of cores of baked moulding sand is determined in the manner already described, and the strength is usually determined by breaking in tension a briquette somewhat similar in shape to those used in testing cement. In the preparation of test-specimens of cores, the same care and procedure should be used as in the making of the cores themselves. These tests are of greatest value in the study of the properties of core binders, and for such tests a carefully selected, washed and dried silica sand, consisting of well-rounded grains between 40- and 70-mesh in size, with at least 95 per cent. of the 70-mesh size, is used.

Shape of Grain.—Although much study has been devoted to the subject of grain shape, no definite statements supported by the results of tests can be made as to the practical aspects of this phase of the subject. The grain shapes of foundry sands are usually classified as: angular, subangular, rounded and compound. By some writers, the rounded grain is considered as the basis of the "ideal" moulding sand.

Chemical Analysis.—A determination of the chemical composition of a moulding sand is not required in ordinary testing. In the study of new deposits and of sands which are, in certain respects, unsatisfactory, chemical analysis must often be relied upon. The determination of the nature and amount of the "fluxing constituents" is often helpful in this respect. A sand may be unsuitable for foundry use because of the presence of particles of undecomposed mica or of feldspar, both of which result in a low-sintering point for the sand. The determination of calcium, sodium or potassium by chemical analysis is useful in such cases in establishing the cause of the inferiority of such sands.

Grading and Choice of Sands.

Grading.—A number of classifications of mouiding sands have been recommended by the Committee on Moulding Sand Research of the American Foundrymen's Association. The class designations serve to define rather closely a sand for foundry use. In addition to giving the grain-fineness number and the grain shape, the sand may be classified according to the grain fineness and the clay content. These classifications are given in Tables V and VI.

A Choice of Sands.

Only very general recommendations can be given to cover the choice of sands for specific uses. The information given in Table VII, which is based largely upon experience, is intended as suggestive rather than in the nature of a categorical reply to the question often asked of this Bureau as to the proper sand for a certain specific use.

Accuracy of Large Rolls.—An article in a recent issue of "The Iron Age" states that chilled rolls for producing ultra-thin coatings (rubber, etc.) are frequently 8½ ft. long and 2½ ft. dia., and the accuracy in roundness of some of the smaller rolls used for coating paper is 0.0001 in. The accuracy in parallelism demanded is such that two rolls running in contact with a strong light behind them will not show a definite ray under close observation.

Nitricastiron.

Mr. J. E. Hurst's Paper* on this subject was discussed by several prominent Scottish metallurgists, and their views are printed below. The discussion was opened by DR. DONALDSON, who said the nitriding process opened up wide possibilities in regard to wear-resisting cast irons, and put cast iron on the same plane as steel. In the table of mechanical properties which the author detailed, the treatment before nitriding was given as heating to 900 deg. C. and cooling in air or oil. The cooling in air was an air-hardening process, and he was rather surprised at the results obtained because the analysis showed 1.6 per cent. chromium, and he considered this was rather a low percentage to give air-hardening properties. Mr. Hurst had referred to the depth of penetration of the nitrided material and had mentioned that there was an outer case of approximately 1/1,000th of an inch of hard material followed by 10 to 16 thousandths of material with a Brinell hardness of 1,000. He would like to know if that figure was obtained after the hard outer skin had been removed. Mr. Hurst had not made any reference to the heat-resisting properties of nitricastiron, and he would be very interested to hear from Mr. Hurst how the material behaved in regard to heat resistance and especially how it compared with nickel-chromium heat-resisting irons.

MR. J. E. HURST, in reply, said that the nitricastiron, as a result of the treatment stated, was only very lightly quenched and did not show very much air hardening. Regarding the outer layer of 1/1,000th of an inch, he was afraid he may not have made the position quite clear. The outer layer was not hard, but friable, and could be removed easily by light polishing; the Brinell number given was after the outer layer had been removed. He regretted that so far he had no information as to the heat-resisting properties of the material. He had not yet investigated that aspect of the material.

MR. MCMANUS said he noticed in the figures given that the total carbon was very low. Was this an essential feature in all irons for nitriding purposes? If so, it presented a difficult proposition for cupola-melted iron.

MR. J. E. HURST said that all his experiments had been made on iron having a total carbon of 2.68, and it was advisable to keep the carbon low, although it did not necessarily follow that it must be kept at that particular figure.

MR. A. CAMPION said that he joined with Dr. Donaldson in congratulating Mr. Hurst upon the valuable research work which he had carried out and the results obtained. He had intended raising the point which Mr. McManus had mentioned, not in regard to the carbon alone but the composition generally. The type of iron used for the purposes for which Nitricastiron was recommended was as a rule low-carbon, close-grained material. He thought the composition of the iron was sure to have some influence on the process, and he would be glad to learn from Mr. Hurst if he had any data showing the influence of silicon and manganese and also of the sulphur and phosphorus. He would like to have an idea of the range of compositions which were suitable for nitriding. He remembered a case of a chemical works about 35 years ago where it was desired to convey ammonia gas through a certain part of the plant, and the difficulty was to find a material which would last for more than a few days. Copper, brass, lead and many other metals and alloys were tried without success. Cast iron was not thought of in those days, when, even if it had been, cast-iron pipes were all too heavy. Wrought iron was tried, and although better than copper and the others did not last very long, and he thought that indicated that there must be a minimum of carbon permissible in the material for successful nitriding. All the examples which Mr. Hurst had shown were of small castings; he thought 36 lbs. was the largest mentioned, and he would like to know whether the process was applicable to larger castings, such, for instance, as a marine Diesel-engine liner of 380- to 500-mm. bore. Was any trouble experienced with excessive volume change in very complicated castings, or was the distortion greater than in ordinary iron? The process was exceedingly interesting, and personally he did not know what the action really was; he wondered if Mr. Hurst could give the theory of the process.

MR. J. E. HURST, in reply, said the effect of composition is of great importance, but this has not yet been thoroughly investigated. The effect of silicon-phosphorus and manganese was being studied. The composition, approximately, as given in the tables, was that which had given the best results so far. It was quite possible to obtain good results with various compositions and he had been successful with material containing 3.0 to 3.2 per cent. carbon. The largest cylinder liner so far made was about 10-12 in. dia. In the case of complicated castings distortion was bound to occur and might cause trouble, but they relied on the skill of the operator to cope with it. Distortion took place in the quenching of ordinary materials. In regard to the mechanism of the nitriding process he refrained from theorising at the present time.

The PRESIDENT said that, unfortunately, there was other business to be attended to, and he had to close the discussion. He thought that everyone present agreed that they had had an excellent Paper and discussion. He asked them to accord to Mr. Hurst a cordial expression of their appreciation of the Paper and for having come to them that day.

* FOUNDRY TRADE JOURNAL, November 2, 1933, *et seq.*

A New 3-in. Diameter Metal Pipe.—In response to the general demand for a lighter type of pipe in smaller sizes, the Stanton Ironworks Company Limited, near Nottingham, have made a notable addition to their range of Stanton Delavaud spun iron pipes. This takes the form of a new 3-in. dia. spun-iron pipe which is ¼ in. in thickness, weighs 1 cwt. per 12-ft. length, and is sold at the greatly reduced price of 2s. 1½d. per yd., f.o.t., from the manufacturers' works.

Although it conforms to the British Standard Specification, and is tested to 200 lbs. per sq. in., the new pipe is not intended to replace the present thicker 3-in. dia. spun-iron pipe. The manufacturers anticipate, however, that it will be adopted by many buyers who prefer cast-iron pipes to those of other materials.

Scottish Pig-iron Trade.—Mr. John Brown, Glasgow, local secretary of the Iron and Steel Trades Confederation, addressing a meeting of iron and steel workers at Parkhead, stated that in his opinion unless a comprehensive and well-planned scheme of reconstruction could be put into operation in the West of Scotland the local blast-furnace trade was doomed to extinction and the foundry and heavy steel industries would be dependent on England for their supplies of pig-iron. The scheme put forward by Messrs. William Baird & Company, Limited, which proposed to supply gas from their coke ovens and blast-furnace plant to Glasgow Corporation was a step in the right direction, and if successful would help to eliminate waste in the manufacture of pig iron and substantially reduce the cost. The blast-furnace trade in Scotland was dependent entirely upon imported ore. In Northamptonshire, where developments were taking place, the iron ore necessary to make a ton of pig-iron cost 8s. into the blast furnace as against 28s. 6d. at the local works in the West of Scotland. Protest meetings and resolutions were useless in face of these economic facts, and the only hope of retaining the industry in Scotland was by co-ordinating production at every stage of the manufacture. Local authorities had a special duty to the community and the extent to which they could assist by finding a market for the by-products of an industry which employed some 20,000 workpeople in the West of Scotland was considerable. They must accept their full share of responsibility and, if possible, fit into any new scheme of industrial re-organisation.

Commercial Moulding Sand Control for the Modern Ironfounder.

By F. Hudson.

(*Concluded from page 360.*)

Permeability.

The same test-piece as used for compression tests is also used for permeability, but instead of using the split form of corebox the sand sample is rammed up in a tubular form of box. This tube is then attached to Richardson's permeability apparatus, as shown in Fig. 4A, and 2,000 c.c. of air is blown through the core by allowing this amount of water to fall from the top tank into the bottom. The pressure of the air being blown through the core is indicated on the manometer, and this is recorded, together with the time of air flow, for calculating the

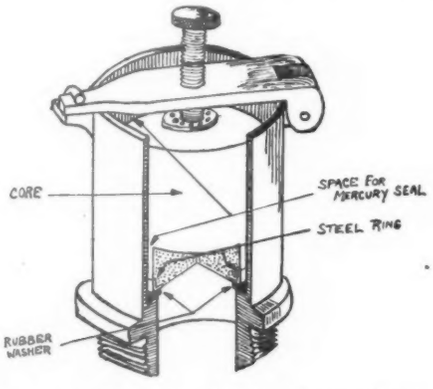

FIG. 6.—MODIFIED A.F.A. MERCURY-SEAL ATTACHMENT FOR RICHARDSON'S PERMEABILITY APPARATUS FOR OBTAINING INDEX OF DRIED PERMEABILITY.

A.F.A. permeability number by the use of the formula given in the previously-mentioned Report of the I.B.F. Sub-Committee on Sands and Refractories.

If the permeability of a dried sample is required, we employ a modified form of the A.F.A. mercury-seal attachment for holding the sand sample under test, as shown in Fig. 6. The size of the core is the same as given for all the previous tests, except that the precaution is taken to ram up a steel ring in the bottom of the core to ensure a satisfactory joint with the rubber washer and prevent leakage of mercury. It is personal practice to take at least four samples of sand per day, and the results obtained are entered upon a daily control sheet, as shown in Fig. 7.

In commercial moulding-sand control it is essential that the results obtained by test should definitely be representative of practical conditions, and it is good practice to satisfy oneself that this is so, at required intervals. The method employed to effect this is by a comparison of the apparent density of moulds rammed up in the foundry with the apparent density of the daily test samples. Table I illustrates the way of doing this. Various moulds are rammed up by different methods and then sand sections are trepanned by means of a steel cutter of exactly the same size as the control test-piece. This sand section is then weighed and it must agree with the weight of sand used for ramming up the test-piece. In some cases it is even possible to actually test the extracted samples for compression.

In ramming up the test-pieces for green-sand work, the standard ramming conditions give an apparent density of 1.47 using 151 grms. of sand, and it will be observed that this agrees quite well with the average ramming conditions obtained in practice on hand and squeeze-rammed jobs. It is preferable to base the average on this class of ramming rather than on jolted work, as this latter method gives a variable apparent density according to the relation of the sample with the pattern face. For jolt-rammed jobs it is convenient to use a penetrometer as devised by Buchanan for obtaining an indication of the comparative densities as obtained in practice with those from test methods. In this Table, one will also observe the comparative results obtained by trepanning compression test-pieces from moulds, against the methods of ramming employed in the routine control tests. It can be definitely assumed from these results that the recommended A.F.A. routine control test methods are comparable with practice.

There are other helpful tests likely to be of value for control purposes, but these have been more fully described elsewhere, and for those interested reference should be made to available literature. In this present Paper probably the only other test likely to receive reference will be the question of gas evolved on heating, and this has been fully covered in previous Papers by the author.

PART II.

Benefits to be Gained by Moulding Sand Control.

After the installation of suitable plant and methods, one is confronted by many problems, and the first aim, no doubt, will be in the direction of producing a suitable sand for safe casting production at lowest cost. Obviously, the best way to undertake this problem is first of all to obtain some reliable idea of those properties required in a moulding sand to produce good castings, and when these have been obtained and standardised, experiments in cost reduction can go ahead. In the particular case of the author, he first referred to all published literature available and abstracted all sand-test values given, relative to the manufacture of general engineering castings. Secondly, the existing sand mixtures which had been in service for several years previously, and known to give fairly efficient results, were thoroughly tested and their physical characteristics determined. Thirdly, the sand practice of other foundries who were operating with similar control methods and producing efficient results, was sought and compared with the results already obtained by the two previous lines of investigation.

TABLE I.—*Influence of Methods of Ramming on Physical Properties of Sands.*

TYPE OF SAND	METHOD OF RAMMING.	MOULD HARDNESS PENETROMETER READING IN CMS. USING 20 GRM WEIGHT.	APPARENT DENSITY OF 5"×2" SECTION TREPANNED FROM MOULD	WEIGHT OF SAND OBTAINED IN TREPANNING TOOL.
GREEN SAND	HAND	2·1	1·50	155 GRMS
		2·5	1·48	152 GRMS.
GREEN SAND	HERMAN JOLTER	2·6	1·37	141 GRMS
		3·3	1·37	
GREEN SAND	OSBORNE JOLTER	4·1, 4·5,	1·34	138 GRMS.
		4·1, 3·5	1·33	137 GRMS.
GREEN SAND	SQUEEZE	3·1	1·46	150 GRMS.
		3·5	1·45	149 GRMS.
DRY SAND	HAND	2·2	1·63	168 GRMS.
		2·1		
DRY SAND	JOLT	1·4, 2·1,	1·64	169 GRMS.
		2·0		

VOLUME OF 2"DIAM × 2" EXTRACTION TUBE IS 105 CCS.
TEST CORE TREPANNED FROM 6" VALVE BODY MOULD JOLTED 150 TIMES GAVE A GREEN COMPRESSION STRENGTH OF 5·5 lbs PER SQ INCH A.F.A. ROUTINE CONTROL TEST CORE MADE FROM THE SAME SAND AS THE MOULD. GAVE A GREEN COMPRESSION STRENGTH OF 5·4 lbs PER SQ. INCH.

Some of the results obtained by these methods are illustrated in Tables II and III. Note should be taken that in the green-sand values given by Dietert in Table II a distinct difference is made according as to how the sand is rammed. For example, if a sand slinger be used for ramming up the moulds, the sand will require to have less moisture and a lower green compression strength than if a jolting machine is employed. This is entirely due to the difference in ramming velocities imparted by the two types of machines. Personal experience entirely confirms the need of this distinction, and, if it is not recognised, trouble will result. Particular note should also be made of the average test limits at the bottom of the Table, especially that referring to the dried compression strength required of 40.0 to 60.8 lbs. per sq. in. for comparison with the sand values given in Table III obtained from dry-sand practice. It will be observed that the limits of dried compression strength obtained on the green sand fall within the limits obtained from dry sand.

DAILY SAND CONTROL TESTS.

GLENFIELD & KENNEDY LIMITED, KILMARNOCK.

DATE 31/10/33

TYPE OF SAND LIGHT FOUNDRY STANDARD GREENSAND

MIXTURE OF BATCH
GREENSAND FLOOR SAND PLUS 0·6% COAL DUST 0·125% WOOD EXTRACT

TEST.	TIME A.M. 10·0	12·0		TIME P.M. 2·0	4·0		DAY'S AVERAGE
% MOISTURE	6·8	6·6		6·6	6·6		6·65
GREEN COMPRESSION A.F.A. Lb PER Sq In	6·5	6·1		6·8	5·9		6·3
GREEN COMPRESSION B.C.I.R.A. Lb PER Sq In	4·0	3·8		3·9	3·7		3·9
GREEN PERMEABILITY. A.F.A. NUMBER	80·0	85·0		78·0	79·0		80·5
DRIED COMPRESSION A.F.A. Lb PER Sq In	61·4	60·8		67·2	73·6		65·8
DRIED COMPRESSION B.C.I.R.A. Lb PER Sq In	24·5	29·0		26·5	28·0		25·8
DRIED TRANSVERSE Lb PER Sq In BROKEN OVER 4 CENTRES	-	-		-	-		-
DRIED PERMEABILITY A.F.A. NUMBER	-	-		-	-		-

REMARKS -
APPARENT DENSITY OF A.F.A. TEST PIECES = 1·47
APPARENT DENSITY OF B.C.I.R.A. TEST PIECES = 1·49
NO TROUBLE IN FOUNDRY DUE TO SAND QUALITY

FIG. 7.—DAILY SAND CONTROL TESTS.

Obviously, if one could increase the dried strength of green sand by a certain margin there would be no need for using a separate sand mixture for dry-sand work, and it should be possible to develop a single sand mixture for both duties. After all, why should green sand be any weaker in the dried condition than a dry-sand mixture? The only difference affecting this question is in regard to the coal-dust additions and in methods of mixing, and after due consideration it was decided that this point constituted a valuable line of thought for future research work.

It will, no doubt, be agreed that Tables II and III give some definite idea of those properties required of the sand to produce good castings and permit sand tests to become a definite means of control. It will be appreciated that all this was not done in a few days. In fact, to be perfectly candid, before the Laboratory had decided on what test methods to adopt, and the necessary test limits required for control, the best part of twelve months had elapsed. In the meantime, the new sand plant had been operating steadily on green sand, using a temporary standard mixture consisting of approximately:—94 green-sand floor sand; 3 rock sand; 1½ red sand, and 1½ per cent. coal dust.

The cost of new sand additions and coal dust in this mixture worked out at about 1s. 6d. per

ton, and at the time this was thought to be quite economical. Unfortunately one is apt to forget the capacity of the plant, and even whilst running at reduced capacity of around 80 tons per day it was soon found out that so far as the reduction of new sand costs were concerned it was fallacious. In fact, after some months' running it was found that the cost of the sand additions was going to be well above that used in the old system of working when facing sand was employed, backed up with the floor sand prepared by the moulders. Fortunately the sand-control tests had now started, and very soon we found out that the "economical mixture" was most un-economical, and the position at this time is clearly exemplified in Table IV. It will be observed that when routine daily control tests commenced it was found that the green sand in service was altogether too rich, and it was decided to reduce bond. Obviously the most economical way of doing this was to run the plant without any additions whatsoever, and this course was accordingly adopted. At the end of one month the sand was still in satisfactory condition after handling between 400 to 500 tons of light to medium-weight castings. At the end of two months about 1,000 tons of castings had been made, and in the light of present knowledge the sand did not really need any additions so far as its value for safe casting production was concerned; however, at that time the atmosphere in the foundry was highly charged with tension and liable to explode figuratively at any moment, and it was decided that some addition had better be made to the sand to prevent the risk of a sudden increase in defective castings.

The only property of the sand which needed adjustment, according to the routine tests, was the dried strength, which recorded a test figure at the end of this two-month period of 28.4 lbs. per sq. in. compression, using the B.C.I.R.A. form of test-piece rammed by Buchanan's double-compression method. This had to be increased without increasing the green-bond strength, and thus the first problem was born, and overcome by the use of a small addition of liquid wood extract. It is obvious that additions of new sand, or of clay, would have increased the green-bond strength as well as the dried strength, and this was undesirable, as some slight trouble had already been experienced due to the sand lacking that property of "flowability" so essential for rapid production on jolting machines, and which constituted the main percentage of mould output. Much more could be said about our trials and tribulations in these earlier stages of sand control, but in view of other considerations the subsequent developments can probably be more readily seen by a survey of Table IV.

To summarise the question of the necessary additions required to keep green sand in safe working order, one must first have absolute faith in the results shown by the control equipment, and the required additions can then probably be divided into three groups, as follow:—(1) To increase the green-bond strength, add clay either in the form of one of the colloidal clays on the market such as Bentonite, or alternatively in the form of finely-ground fireclay or new moulding sand; (2) to increase the dried strength use wood extract; and (3) adjust coal dust to suit the sand according to the percentage of gas evolved.

If sand-control tests are properly applied, and if satisfactory and efficient methods of preparation are available, it should definitely be possible to produce a green sand suitable for the bulk of general grey-iron engineering castings from a mixture containing 99 per cent. of floor sand, and from personal experience of the sand practice of many foundries such a result cannot but be a considerable economic advantage as well as a striking argument for a greater interest in sand control.

It is considered, however, that the success of this result depends to a large degree upon the removal of iron particles from the returned sand, and the fitting of some form of magnetic separator as an integral part of sand-preparation plants is essential.

Before leaving Table IV, it is interesting to note that after five months' service the permeability of the sand has progressively improved. This is partly brought about by the fact that we do not worry about the green sand becoming contaminated with burned oil sand from cores, within reasonable limits, and also due to the fact that the mixing mills are of an efficient design. It would appear that the "silting up" of moulding sand, so far as cast iron is concerned, is largely dependent upon the sand-preparation methods employed and the intelligent use of control tests.

In Table V is appended a comparison of results before and after the installation of sand-control methods. No claim is made to have reached perfection in this direction, but it is thought it will be admitted that by the use of systematic tests it is possible to effect very substantial cost reduction in new sand supplies. For comparison there is included in this Table the sand values already shown as giving good results, and it is interesting to observe that after seven months' service the sand is still much better than it requires to be notwithstanding the economical additions, and this point but gives added emphasis to the need for every foundryman to take a keener interest in the subject which forms the text of this Paper to-night.

In working with such small additions of new materials the problem of making up sand losses is an important one, and it is, do doubt, obvious that this aspect must also be under careful control. Undoubtedly, the first point is to ensure as little sand loss as possible, and much can be done in this direction by the adoption of proper supervisory methods by the foundry staff. With due care sand losses can be kept at a low level, and at certain intervals the loss can be made up by the reclamation of burned core sand. The practice adopted by the author entails the rebonding of this sand with colloidal clay, and a typical mixture giving satisfactory service is as follows:—40 green-sand floor sand; 60 burned core sand; 2 Bentonite; and 1 per cent. coal dust.

Such a mixture will cost around 7s. per ton. The idea of using a certain percentage of floor sand in conjunction with the reclaimed core sand is to reduce the amount of Bentonite required, and so effect rebonding at the lowest possible cost. The use of colloidal clay has many economic advantages in modern methods of sand control, and, if time had permitted, many interesting applications could be discussed. It may be of interest to mention, however, that a recent survey of rebonding clays available to the foundry trade indicate that there are about three types showing promise for service in this direction, and if these be arranged in order of merit, placing Bentonite first with 100 per cent. rebonding efficiency, the comparison is as follows:—Bentonite, 100 per cent.; Colbond, 50 per cent.; certain dry ground fireclays, 20-25 per cent.

Whilst perhaps the greatest value of proper sand control lies in regard to conservation and reclamation, there are many other directions in which systematic tests can benefit the practical worker. A good sand is essential for modern economic production methods in at least two major directions. Firstly, a good sand makes the moulder's work easier and consequently tends to increase output. Secondly, a good sand is essential for good castings.

Good Sand Makes the Moulder's Work Easier.

If a census be taken of the most widely-used moulding machine, probably it will be found

Table II.—*Green-Sand Values known to give Good Results.*

AMERICAN

Kind of Casting	Type of Ramming	% Moisture	Compression Strength lbs per sq. inch. Green. AFA	Green. B.C.I.R.A.	Dry. AFA	Dry. B.C.I.R.A.	Permeability AFA No.	Gas evolved from 50 grm. dried sand at 1000°C c.c. per minute	% Loss on Ignition	Authority
Fly Wheels	Jolt	6½/7·5	4·6	-	40·0	-	90·0	-	-	Dietert
Fly Wheels	Sand Slinger	6·0/7·0	4·1	-	40·0	-	100·0	-	-	Dietert
Pipes	Jolt	6·0/7·0	4·0	-	46·0	-	300·0	-	-	Dietert
Car Wheels	Jolt	7·5/8·5	4·7	-	40·0	-	130·0	-	-	Dietert
Cylinder Blocks	Jolt	6·0/7·0	3·0	-	44·0	-	80·0	-	-	Dietert
Cylinder Blocks	Sand Slinger	6·5/7·5	4·0	-	42·0	-	80·0	-	-	Dietert
BRITISH (Apparent Density of British Samples all 1·55)										
Railway Chairs	Hand	6·5	3·1	2·9	52·7	19·4	30·2	65·3	8·1	Ben Nigd.
Hydraulic Valves	Hand + Machines									
Facing Sand		7·0	4·6	3·0	60·8	21·0	49·1	70·0	7·2	F. Hudson
Backing Sand		7·0	5·0	3·5	48·7	15·5	43·4	68·3	7·1	F. Hudson
Average Limits	From	5·5	4·0	2·9	40·0	15·5	30·2			
	To	9·0	5·1	3·5	60·8	21·0	300·0			

* Dried and heated to 1200°C for ½ hour.

Table III.—*Dry-Sand Values known to give Good Results.*

British General Engineering Castings up to 10 tons

Kind of Casting	% Moisture	Compression Strength lbs per sq. inch. Green AFA	Green B.C.I.R.A.	Dry AFA	Dry B.C.I.R.A.	Permeability AFA No.	Gas evolved from 50 grm. of dried sand at 1000°C c.c. per minute	% Loss on Ignition	Authority
Medium Weight	(The apparent density of tests is 1·65)								
Facing Sand	9·3	8·3	6·4	125·1	112·0	79·0	56·6	4·9	F. Hudson
Backing Sand	9·0	6·1	4·5	66·1	34·0	66·3	55·7	4·5	F. Hudson
Heavy Weight									
Facing Sand	9·0	9·0	7·8	114·3	73·0	61·5	53·9	4·4	F. Hudson
Backing Sand	10·2	5·3	2·5	40·1	12·5	67·5	56·3	4·2	F. Hudson
Average from	9·0	5·3	2·5	40·1	12·5	61·5			
Limits to	10·2	9·0	6·4	125·1	112·0	79·0			

* Dried and heated to 1200°C for ½ hour.

Table IV.—*Illustrating Methods of making Green Sand Additions Based on the Results obtained from Daily Control Tests.*

% Moisture	Green Compression lbs per □" A.F.A.	Green Compression lbs per □" B.C.I.R.A.	Green Permeability A.F.A. No.	Dried Compression lbs per □" B.C.I.R.A.	Gas Evolved in c.c. per min.	% Ignition	Remarks
6·56	8·7	5·5	53·6	50·0	98·0	9·3	5/4/33 Control started, sand too strong, so plant allowed to run until tests showed need of additions.
6·0	7·3	5·0	72·2	28·4	88·8	7·8	10/5/33 Dried strength beginning to deteriorate addition of ½% wood extract made.
5·82	6·5	4·4	78·4	33·0	64·3	6·72	7/6/33 Dried strength regained by wood extract addition omitted. Gas evolved shows need of extra coal dust, 0·6% coal dust addition made.
6·9	6·6	4·0	57·0	28·5	90·9	8·3	22/8/33 Coal dust addition stopped. Plant allowed to run without any additions.
6·58	6·0	3·8	69·3	24·0	79·4	8·4	26/9/33 Green and dried strength beginning to deteriorate so 0·75 – 1·5% rock sand added and 0·125% wood extract
6·55	7·0	4·5	95·1	42·4	68·5	7·0	16/10/33 Green and dried strength regained but gas evolved shows need of coal dust so 0·6 addition recommended

Table V.—*Result of Sand Control on Physical Properties.*

Light Foundry Standard Green Sand — Date 27·3·33

Mixture :- 94% Old green sand floor sand
3% Rock Sand
1½% Red Sand
1½% Coal Dust (additions cost 1/8d per ton)

Average test results before sand control

	% Moisture	Compression Strength lbs per sq. in. Green AFA	Green B.C.I.R.A.	Dry AFA	Dry B.C.I.R.A.	Permeability AFA No.	Gas evolved from 50 grm. of sand at 1000°C c.c. per min.	% Loss on Ignition
Sand in service 27·3·33	6·6	8·7	5·5	-	50·0	53·6	98·0	9·3
Greensand values known to give good results (Table 2)	5·1/5·0	4·0/5·1	2·8/2·5	100·5/104·8	19·5/21·0	30·5/29·8	80·5/79·0	7·1/8·1
Drysand values known to give good results (Table 3)	5·0/5·2	3·3/3·0	2·5/2·4	40·1/45·1	12·5/12·0	84·5/79·0	33·8/30·4	4·2/4·5
Sand in service 20·10·33	6·6	6·5	3·8	62·1	30·5	77·7	86·6	9·0

Average test results after sand control

Mixture :- 99·075% Old green sand floor sand
0·800% Coal dust
0·125% Wood extract (additions cost 7d per ton)

that the "jolter" heads the list, and from the sand point of view it is certainly the most interesting. At a foundry social event an apt conundrum would be something like this:—"Why doesn't the jolter jolt," and the answer might be: "Because the moulder will ram, and the sand won't." No doubt the meaning is obvious, but it is surprising how much auxiliary hand ramming is required to supplement the action of this type of machine using the natural sands of Britain, whilst observations abroad,

TABLE VI.—*Physical Properties of Sands used for Flowability Tests on Herman Jolting Machine.*

TEST	WEAK SAND	STANDARD SAND	STRONG SAND	VERY STRONG SAND
% MOISTURE	6·2	7·3	6·7	6·5
GREEN COMPRESSION STRENGTH A.F.A. LBS PER SQ. INCH	5·4	6·5	8·4	10·1
GREEN COMPRESSION STRENGTH B.C.I.R.A. LBS PER SQ. INCH	3·7	4·0	4·5	5·6
GREEN PERMEABILITY A.F.A. N°	71·1	58·1	65·5	64·1
DRIED COMPRESSION STRENGTH B.C.I.R.A. LBS PER SQ. INCH	17·0	29·0	33·5	46·5

MIXTURES:-	(ALL SANDS MILLED FOR 3 TO 6 MINUTES)
WEAK SAND	60 SHOVELS STANDARD GREEN SAND PLUS 16 SHOVELS SEA SAND
STANDARD SAND	60 SHOVELS STANDARD GREEN SAND ALONE
STRONG SAND	60 SHOVELS STANDARD GREEN SAND PLUS ½ SHOVEL BENTONITE
VERY STRONG SAND	60 SHOVELS STANDARD GREEN SAND PLUS 1 SHOVEL BENTONITE

particularly in the United States, definitely show that production is invariably obtained without this extra ramming. Undoubtedly the reason lies in the physical properties exhibited by the sand and particularly by that property called "flowability."

"Flowability" is an index of the ability of the sand to flow under ramming energy to form a smooth, uniform surface against the pattern. Obviously, if a sand possesses too much green bond the "flowability" will be low, and if such a sand is used on "jarring" machines one is apt to obtain soft patches or voids, unless the hand rammer is brought into play. Conversely, if the sand has too little bond, whilst the ramming may be conducted satisfactorily, it will be probable that bad pattern draws will be experienced, extra gaggers will be required to hold the sand together and probably drop-outs will occur on top parts when turned over for closing.

The suitability of any particular sand for service on jolting machines is primarily dependent upon individual practice, and no definite test

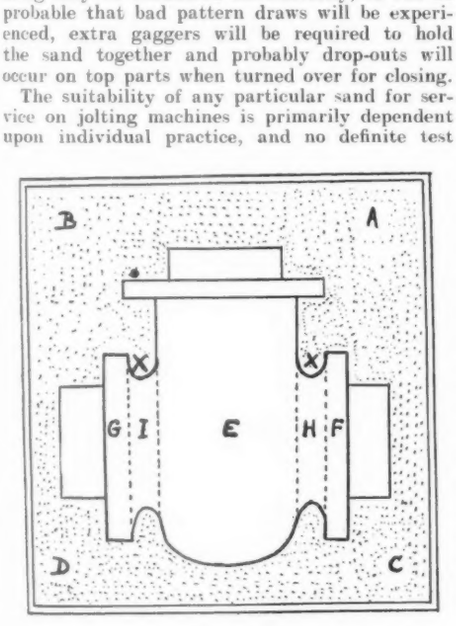

FIG. 8.—POSITION OF HARDNESS TESTS IN EXPERIMENT IN SAND FLOWABILITY.

limits can be offered, but it may be of interest to outline a typical example of the effects of "flowability" in this direction. A new Herman machine was recently installed in the foundry for the manufacture of valve bodies over a range of sizes and to save cost a standard moulding box was designed to take the necessary range of casting sizes. It will be appreciated that when the smallest size of casting was made the sand "hang" was considerable, and when the top half was turned over for closing, very often partial "drop-outs" occurred. Accordingly, an investigation was conducted in order to determine the most suitable sand for production purposes, and the methods adopted were as follow:—A series of half boxes of the smallest valve body made on the machine were rammed up in four sands having various green-bond strengths, and these were jolted for different times. Hardness tests were then conducted on the mould face by means of Buchanan's Penetrometer and the "hanging" properties of the sand gauged by turning the rammed box parts over and striking the box sharply on alternate sides with an iron bar, the number of blows required to cause the sand to drop being accepted as an index in this direction. Table VI illustrates the physical properties of the sands used, varying in green-bond strength from a weak sand having only 5.4 lbs. per sq. in. compression strength up to a very strong sand having a strength of 10.1 lbs. per sq. in.

From each of these sand mixtures half-moulds were made, giving the machine 50, 100 and 150 jolts, and hardness tests were then conducted at the positions shown in Fig. 8. In Table VII are tabulated the average hardness values obtained. These are most interesting. Considering the test using weak sand first, it will be noticed that greatest uniformity so far as mould hardness is concerned is obtained after 100 jolts. If more or less than 100 jolts are given to the mould, this variation is greater than that obtained with 100-jolt period. In the case of the standard sand, greatest uniformity is again obtained after 100 jolts. Furthermore, by the use of the standard sand maximum, hardness values are obtained for any given jolting period, and it will be observed that the hardness of the mould face is greater than when weaker or stronger sands are used. In fact, as the sands become stronger, the hardness of the mould face becomes less, due, in all probability, to the jolt impact not being of sufficient intensity to compact the more strongly bonded sands, and this gives a very definite indication that sands having a greater green-bond strength than the standard sand shown in this table are not likely to give good results so far as uniformity of ramming is concerned.

It is considered that the hardness of the rammed face bears a definite relation to the question of "flowability" and consequent troubles of "bridging," soft spots and distorted castings. From previous observations conducted it was known that the average hardness obtained generally from satisfactory moulds was in the order of 21 m/m., and it should be noted that in these present tests the moulds made from the standard sand after 100 jolts most nearly approximate to this figure, consistent with uniformity over the mould face. Particular note should be taken of the column in Table VII, giving the variation in penetrometer values over the mould face, as this provides an excellent index for sands having "bridging" tendencies, and the higher the variation the greater the tendency for this trouble to occur.

Table VII gives an indication relative to the amount of green bond required from the sand to minimise "dropping." The final conclusions reached by this series of tests indicate that the standard sand having physical properties as shown in Table VI will give the most satisfactory results for moulds made on the Herman machine. A safe limit so far as the green compression strength is concerned would be as follows:—On A.F.A. apparatus, 5.7 to 7.0 lbs. per sq. in. at 7 per cent. moisture; on B.C.I.R.A. apparatus, 4.0 lbs. per sq. in. at 7 per cent. moisture. With sand of this strength it requires 100 jolts to effect uniform compaction. If a weaker sand is used, there will be liability for "drop-outs" to occur, and if the sand is stronger, "bridging" and variation in mould hardness will arise. "Drop-outs" due to weakly-bonded sand can be corrected within limits by a longer jolting time, but there is no correction for "bridging" if the green-bond strength is high.

In quoting these tests as an example of the further value of sand tests to the practical worker, it is intended mainly to illustrate test method, and due consideration must be given to one's own individual practice in the acceptance of these results. Moisture control is a very vital

TABLE VII.—*Mould Hardness Values obtained from Various Sands after Jolting for Various Purposes.*

SAND USED	N° OF JOLTS GIVEN	AVERAGE PENETROMETER VALUES IN M/M AT POSITION				VARIATION IN PENETROMETER VALUES OVER MOULD FACE
		A.B.C.D	E.	F.G.	H. I.	
WEAK	50	27	30	22	36	14
	100	24	24	22	28	6
	150	20	23	16	28	12
STANDARD	50	23	26	24	34	11
	100	19	20	17	22	5
	150	18	18	17	22	5
STRONG	50	29	29	27	40	13
	100	24	20	20	29	9
VERY STRONG	50	23	25	24	35	12
	100	23	16	19	30	14

factor in its effect on the flowability of moulding sands, and should be carefully controlled.

At the last Annual Convention at Cardiff, in the discussion on the Report of the Sands and Refractories Sub-Committee in reference to test methods for green sand, some mention was made relative to the value of compression tests as an indication of the "lifting" properties of a sand, and here again the question of "flowability" arises.

Mr. J. Hird mentioned a case where a sand giving a higher compression reading on test did not necessarily give a better "lift" in practice. This is not by any means an isolated case, for in conducting the test the method of ramming ensures a satisfactory degree of compaction even from strongly-bonded sands, and the factor of "flowability" is not of great moment. For example, let us assume that the test-piece gives a reading of, say, 10 lbs. per sq. in. compression. In practice, however, particularly in connection with machine moulding, the factor of flowability enters, and, if strongly-

TABLE VIII.—*Resistance of Rammed Sand against Dropping in Top Parts.*

SAND USED	N° OF JOLTS GIVEN	REMARKS AS TO WHETHER MOULD DROPPED ON TURNING BOX OVER	N° OF BLOWS STRUCK BOX TO CAUSE SAND TO DROP
WEAK	50	FILLETS AT X (SEE FIG N°8)	ONE
	100	AS ABOVE	TWO
	150	AS ABOVE	FIVE
STANDARD	50	FILLETS AT X (SEE FIG N°8)	THREE
	100	CORNER OF MOULD DROPPED	FIVE
	150	NO DROP	FOUR
STRONG	50	NO DROP	THREE
	100	NO DROP	FOUR
VERY STRONG	50	NO DROP	SIX
	100	NO DROP	NO DROP AFTER SIX BLOWS

NOTE:- AN IRON OR GAGGER IS USUALLY PLACED AT FILLET X BUT IN THESE TESTS THIS WAS OMITTED INTENTIONALLY.

bonded sands are employed, exactly the same conditions can arise, as exemplified a few moments ago in connection with the tests on the Herman jolting machine, and if compression tests be trepanned from moulds rammed up in the shop, instead of a figure of 10 lbs. being obtained, probably only 5 lbs. or less will be evident. Accordingly, it is wise to consider the influence of "flowability" in this direction, and to allow for it.

Good Sand is Essential for Good Castings.

Sand control obviously helps in the prevention of defective work, and one instance has already been given of its value in this direc-

tion in connection with the property of "flowability." Of other instances which can be cited from personal experience in green sand during the last few months, one stands out with particular prominence, and that is in connection with that defect known as a blind or dumb scab. This is illustrated in Fig. 9. It is generally believed that the cause of this defect is due to lack of permeability in the sand or contributory factors, such as hard ramming, excessive moisture, etc. In the particular example under consideration our sand tests showed very definitely that these causes were not responsible for the defect, and indicated that the cause of the trouble must be looked for elsewhere.

In the scientific researches conducted upon refractories it has been found that silica expands upon heating, and as silica constitutes the base of all moulding sands, it is obvious that this expansion is also present in this latter material. The expansion takes place quite suddenly at relatively low temperatures between 500 to 700 deg., and results in a volume change of about 1.0 per cent. It is feasible to suppose that the sudden heating of the mould arising during casting causes this expansion to take place, and in certain instances, dependent on many factors too numerous to mention in this Paper, slight buckling of the sand surface takes place. If due thought be given as to the form the sand buckle is likely to assume, due to these expansion stresses, and reproduce upon the casting surface, one is immediately struck by the marked similarity of this defect with that known as a "blind scab."

Furthermore, it is feasible to conclude that if, at the time when the sand increases in volume, a volume contraction of similar order could be brought about, or provision made for the bond between the grains to become plastic, and so allow the mould surface to yield slightly without buckling, the defect would be prevented or minimised. This line of argument is at present being closely investigated, and it was hoped that the results obtained could have been incorporated in this Paper, but unfortunately they are not yet completed. However, it has definitely been found that the addition of coal dust to green sand has a marked effect in reducing the expansion arising on heating, and it is now standard practice in the author's foundry to add excess coal dust for the prevention of blind or dumb scabs in certain castings. Incidentally, Mr. Ben Hird, who has done such excellent work in investigating the effect of coal dust on green sand, confirms this fact by his own experiences.

Up to this point it has been shown that commercial moulding-sand control has a definite value in the modern foundry in reducing the cost of production along two well-defined lines. Firstly, it effects conservation, reclamation and standardisation of existing sand supplies, and these advantages react to give the second value of increased production of good castings. The third and last advantage which suggests consideration is the value of sand control as applied to practical research and consequent future progression, and no better example can be taken than the production of a sand equally suitable for green- or dry-sand moulding purposes, and for want of a better term this can be called "green-dry-sand."

"Green-Dry-Sand."

The question of green sand *versus* dry sand is one of keen controversy between practical workers, and the result of any discussion on this matter can extend indefinitely. The reason why this state of affairs exists is probably due to the fact that in the past knowledge of the moulding sands used for the production of castings has been most vague, and any real progression in this direction must arise through the more extended application of sand tests.

The average green sand in use in British foundries to-day is far from being foolproof, and its safe application to the larger casting sizes in the past has depended undoubtedly upon the skill of the moulder making the casting. Unfortunately, as pointed out at the beginning of this Paper, modern mass-production methods do not lead to the preservation of the highly-skilled green-sand moulder, and this reaction is evident to-day by the fact that one sees fewer and fewer of the larger castings being made by this method. From the economic viewpoint the extended use of green-sand moulding has much to recommend its more widespread adoption to larger castings,

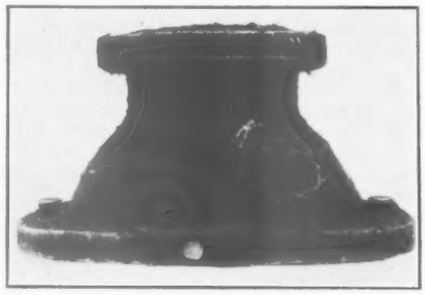

Fig. 9.—"Blind" or "Dumb" Scab.

and it is felt that if foundry executives had more confidence in green sand this would to a large extent make up for any effect modern conditions have played upon the work of our craftsmen. Obviously, this confidence can only be obtained by coming into closer contact with green sand and getting to know each one of its characteristics better, and these can only be shown by the use of sand-control tests.

In the author's works this problem of the production of a single sand for both green- and dry-sand moulding purposes has received considerable attention, and is considered a feasible solution to the economic production of the larger casting sizes. After all, what constitutes the difference between green sand and dry sand? A superficial analysis of this question tends to show many differences. For example, the average dry-sand mixture to-day differs from green sand inasmuch as it contains more moisture as moulded, it has a greater green-bond strength, it has a greater dried strength. It usually evolves less gas on casting, due to the absence of coal dust, but invariably is not so permeable as green sand. If these points be carefully sifted, it will be found that the only real difference so far as the practical application of the two sands are concerned hinges on the question of greater dried strength. Give green sand the dried strength of its competitor, and there will be a far better medium for the production of castings, for even if one is still dubious about making large castings from it in the green state, one can dry the moulds more rapidly, as it contains 50 per cent. less moisture. Such sand does not crack during drying so much as dry sand, and lends itself particularly to the production of skin-dried moulds. Less power is also required for ramming.

Table IX.—*Showing the Development of Green Dry Sand as a Moulding Material.*

Test	Old Green Sand		Controller's New Standard Green-Dry Sand No. 1	Old Dry Sand		Controller's New Standard Green-Dry Sand No. 2
	Facing	Backing		Facing	Backing	
% Moisture	7·0	7·0	6·65	9·5	9·0	7·5
Green Compression A.F.A. Lbs per sq. inch	4·6	5·0	6·3	8·3	6·1	4·4
Green Compression B.C.I.R.A. Lbs per sq. inch	3·0	3·5	3·9	6·4	4·3	3·25
Green Permeability A.F.A. No.	49·1	45·4	80·5	53·0	-	119·0
Dried Compression A.F.A. Lbs per sq. inch	60·8	48·7	65·8	125·1	68·1	147·2
Dried Compression B.C.I.R.A. Lbs per sq. inch	21·0	15·5	25·8	112·0	34·0	149·0
Dried Transverse Lbs per sq. in broken over 4" centres	-	-	-	7·02	-	7·5
Dried Permeability A.F.A. No.	-	-	-	79·0	68·5	130·0
Approximate Mixture	37½% old 30·1% new 37½% coal dust	Old sand plus new sand at discretion not filled	80–97½% old 3–20% new coal dust	33·0% old 33·0% new	Old sand only not filled	98% old green sand plus 2% coal extract filled
Cost per Ton	9/2	9	7	6/3	-	3/5

Note:- Green Dry Sand No. 1 is just about as strong as old dry sand backing sand and can consequently be used with No. 2 sand as facing to replace dry sand mixtures.

The easiest way to increase the dried strength of green sand is by the addition of wood extract, and the effect of this from the dry-sand view is shown in Table IX. This table gives a comparison of the average properties of green and dry sand as used in the foundries of Messrs. Glenfield & Kennedy, Limited, before the installation of commercial control methods, against that obtained to-day using our standard green-dry sand. It will be observed that the controlled sand is vastly superior to old mixtures, and it may be of interest to mention that during the summer months in some instances castings normally made in dry sand were moulded from the standard green-dry sand containing 1 to 2 per cent. wood extract, air dried for a few hours by exposure to the foundry atmosphere and cast the same day with complete success.

Since the installation of sand control, the main benefits noted are:—(1) Reduction in cost of new sand; (2) increased production of finished moulds; and (3) reduction of defective work; and these alone have afforded excellent savings to the firm and paid an excellent interest on the expense incurred by the installation of the new plant and control methods.

In conclusion, it should be pointed out that it is felt that some of the points mentioned in this Paper have not been so fully outlined as they might have been, but indulgence is asked in this matter, as, no doubt, it will be appreciated that to have corrected this omission, the Paper would have been unduly long. Furthermore, it should also be understood that personal work in this direction has not been long started, and is still yet uncompleted, and this to some extent has prevented more detail being given.

Before closing, the author desires to record his thanks to Mr. H. Gardner and the directors of Messrs. Glenfield & Kennedy, Limited, for their very active co-operation in providing the excellent facilities for sand control in our foundries, and for their permission to pass on some of these results to the industry.

More German Ships to be Salved.—An attempt is to be made to salve more of the German ships scuttled at Scapa Flow. A large cargo steamer is being converted at Grangemouth into a salvage vessel to the order of Messrs. Metal Industries, Limited, of Rosyth, the scrap metal firm who have taken over the salvage work carried on until recently by Cox & Danks, Limited. It is hoped that it will be possible to recover eight more of the former German warships. Operations will be begun early in the spring of next year. An official of Messrs. Metal Industries said that they will be in the nature of a great experiment, as the firm has never previously engaged in this line of salvage.

Large Dredge Order for Renfrew.—Messrs. Lobnitz & Company, Limited, engineers and shipbuilders, Renfrew, have received an order for a large gold dredge for working in the alluvial valleys of the river Pek, on the Jugoslav-Roumanian border. These goldfields are of historical interest, as it is said that it was from this region that Alexander the Great secured the gold to finance his expedition to the Himalayas in 328 B.C. The dredge is of large capacity, and is designed to dig and treat 6,000 tons of alluvial gravel per day. It floats on a pond or paddock, and by means of an endless chain of buckets excavates the material in front and lifts it to the screening and washing apparatus. Here the gold is extracted and the waste material is rejected astern, and by this means the dredge traverses the alluvian plain, carrying its own pond along with it. Messrs. Lobnitz & Company, Limited, have had very extensive experience in the design and construction of this class of dredge, and during the last fifty years have supplied plant to nearly all the alluvial-bearing districts throughout the world.

The Institute of British Foundrymen.

SCOTTISH BRANCH ANNUAL DINNER.

The annual dinner of the Scottish Branch was held in the Grosvenor Restaurant, Glasgow, on December 9.

Mr. J. Currie (Branch-President) presided, and was supported at the high table by Bailie Jas. G. Roberton, Senior Magistrate of Glasgow; Mr. C. E. Williams, President of the Institute; Sir Arthur J. C. Huddleston, C.M.G., O.B.E., M.A., Director of the Royal Technical College; Mr. R. M. Allardyce, M.A., LL.B., Director of Education to the Corporation of Glasgow; Mr. Frank S. Russell, Sheffield; Mr. D. M. Semple, managing director of Messrs. Mirrless Watson Company, Limited; Professor A. L. Mallanby, D.Sc.; Mr. Vincent Delport, London; Mr. John Cameron, Past-President of the Institute; Mr. J. Menzies, managing director of North British Steel Company, Limited, Bathgate; Mr. Daniel Sharpe, Branch Vice-President, and Mr. T. Makemson, General Secretary.

City of Glasgow.

After the loyal toasts had been honoured, MR. FRANK S. RUSSELL, of Sheffield, in proposing the "City and Corporation of Glasgow," said that he had recently returned from a visit to many Continental cities, and he could say that in comparison with those cities Glasgow had nothing to be ashamed of, and the only apology it had to make was for its climate. He had been interested to find in Aleppo and Milan large posters advising the inhabitants to spend holidays in Scotland and travel L.M.S. Travelling on the boats one was reminded of Glasgow, by looking at the name plates of the engineers. "Built in Glasgow" stood for the maximum efficiency. The Institute was playing its part in the city's advancement, and generally ensuring that whatever industry may be retrograde it is not that of making castings. As the second city of the British Empire, Glasgow had certain achievements, and for that they had to thank the Corporation. Although the city had been suffering as a result of trade depression, now so happily lifting, the citizens could justly claim that they belonged to no mean city. In conclusion he wished to ask a somewhat impertinent question. Was there anyone whose duty it was to see that new industries were attracted to the city? Because that was what was wanted. He suggested that the new Cunarder could soon be finished if all the threepenny bits were sent to a central fund to be used for that purpose. That would be a fine opportunity of advertising Glasgow. He coupled with the toast the name of their senior magistrate, Bailie Roberton.

BAILIE JAS. G. ROBERTON, in replying, said that in the first place the name of Roberton was not unknown in the foundry industry of Glasgow district. His father's father was an ironfounder in the Gorbals and later removed to Kirkintilloch, where his father carried on the industry. His father in due course took in a partner, and he was very pleased to see in the room that partner's son, Mr. John Cameron. The Corporation had 33,000 employees, which meant that they had the welfare of the city at heart, even if they did sometimes become dissatisfied with the party in power and cast their votes in the other direction. There were signs of the big Cunarder being restarted soon, and he was looking forward to next year being a good one for industry. In regard to new industries, he informed Mr. Russell that there was a development council whose duties were to attract new industries to the district. A few new small industries had already been brought in as a result of the council's activities. The shipbuilding industry was reviving, and he hoped that as a result of the combination in the shipping industry the Cunarder would soon be under construction again, together with a sister ship.

The Institute.

MR. R. M. ALLARDYCE, M.A., LL.B., in proposing the toast of the "Institute of British Foundrymen," said that in it there was a pooling of ideas, but the pooling must be not only within the Institute but with the educationists. The foundrymen had shown their willingness to do that in a very practical way by founding a scholarship, and he hoped many of the members of the Institute would be present at the opening of the new school. It was only by such co-operation that we should get what Germany had won before the war. As representing the educational interests, he had the greatest pleasure in wishing the Institute of British Foundrymen every success.

MR. C. E. WILLIAMS, President of the Institute, in replying said he had a great pleasure in visiting Glasgow, because as a Welshman he felt that he was in a place of long standing friendship. Intense nationalistic tendencies as a result of the war had built up tariff walls which were adverse to the Clyde, and oil and cheap electricity had made the same conditions in South Wales. What could they as members of the Institute do to help the position of their industry which had suffered as a result of the trade depression? He thought they could look to another industry for an inspiration—he referred to the gas industry—which 40 or 50 years ago was thought to have had its death knell sounded, but now one of the soundest investments they could make was in the gas industry. The leaders of that industry got together and by research and the application of commonsense saved the industry. It showed that any industry to prosper must have research. The Institute is helping by the reading of Papers all over the country, and that meant a large amount of research to prepare the Papers, giving assistance to the trade and the nation. They had their own research organisation in the technical commitee, which dealt with all phases of the industry. There was the subject of costing which at first sight was not a subject a body such as the Institute should bother with, but it had nothing to do with wages, and methods of costing could be studied so as to cut out absurd competition which led to waste. Proper costing would eliminate waste, and if this was made generally known he was certain that a brighter future would face them. They in Britain saw slow signs of a trade revival and the too slow reduction of unemployment. Britain was, however, fortunate in having a workable scheme of unemployment benefit, which gave time to watch experiments by other nations. It really made them thankful that they were British.

The International Conference.

MR. VINCENT DELPORT, speaking as the European representative of the American Foundrymen's Association, said that he wished to thank the chairman for granting him the privilege of speaking at that gathering. After a brief survey of the national and international conferences already held, Mr. Delport referred to the invitation which had been received to hold the next international conference in Philadelphia in 1934. He hoped that some of the Scottish members would be able to attend next year to strengthen friendships and to make new ones. He had already started to organise a party of I.B.F. members and delegates from the various countries of Europe. The programme would be available early next year.

Technical Institutes.

MR. D. M. SEMPLE, in proposing the toast of "Technical and Educational Institutions," said that when thinking of educational institutes their minds immediately turned to the Royal Technical College, which is the centre with which much of the work of these societies is associated. It was therefore fitting that he should be in a position to couple the toast with the name of Sir Arthur Huddleston, the new director of the college. Sir Arthur Huddleston had had extensive experience in the political service and as Governor of the Khartoum and Blue Nile Province of the Soudan, and he had also experience as financial and economic adviser to the Soudan Government. He had recently returned to this country after many years of service in Northern Africa, and had undertaken the work previously done by Mr. Stockdale. He (the speaker) wished him success. Some years ago it was his privilege to be closely associated with the modernisation of the sugar industry in a country where it had been established for many years. Very rapid progress had been made. Up to the time of the commencement of this modernisation the average output of sugar was under 200,000 tons over a period of 20 years, whilst ten years later it had increased to 1¼ million tons—over six times as much. This increase involved educating some 15,000 to 20,000 native farmers in modern agricultural practice and science and building up mechanical and chemical staffs for some 40 new factories. One of the most important factors in this progress was the work of a technical society. He asked his hearers not to underestimate the competition to be faced in the future. A short time ago he had the opportunity of visiting a large works which has taken up very extensively the manufacture of fabricated steel, and what he saw there brought home the seriousness of the challenge given to the moulder. Machine parts large and small were being built up from rolled steel sections in a surprising manner; but what struck him very forcibly was the license constructors took with what might be termed conventional design. Before leaving the works he had an opportunity of visiting the foundry, and the conclusion he came to was that if as much ingenuity and enterprise and capital was expended there as in the welding shop many of the articles he saw being fabricated would have been cast, and the product would not only have been better but more cheaply produced.

SIR ARTHUR J. C. HUDDLESTON, C.M.G., O.B.E., M.A., in reply, pointed to the danger of money being wasted by sending men to the universities who could not profit by the courses. Parents must consider very carefully whether their sons are of the right type to profit by a university training. It was also for the employers to make out for themselves whether they wanted men with that higher qualification. The Royal Technical College did not offer a training, but a scientific training upon which the other training could be superimposed.

MR. T. MAKEMSOM, in proposing the "Scottish Branch," said that many of its members took a very active part in the various committees of the Institute. There was, for instance, the technical committee, the object of which was to collect, tabulate and co-ordinate data in such a form that it could be of every-day use to the foundryman. That involved a large amount of devoted work and self sacrifice on the part of the members of the committees. The branch was well managed and a credit to the members, the council, and particularly the secretary. The rise or fall of a branch depended on the virulity of the secretary, and if all branch secretaries were like Mr. Bell the Institute would be in an impregnable position. The branch had been generally lucky in its Presidents, and Mr. Currie was following tradition. The Scottish Branch was firmly entrenched, and whatever weakness

(*Concluded on page* 376)

Foundry Selling Practice.

DISINTERESTED PUBLICITY.

By Eric N. Simons.

Few founders need reminding to-day of the extraordinary and increasing importance of publicity in the modern world. The need of keeping one's name constantly in the public eye is as essential in the technical as in the general field. With the detailed technique of foundry publicity work these articles have dealt in the past; the subject of the present notes is publicity under a different aspect, publicity that costs next to nothing, yet has a considerable monetary value.

Papers to Technical Institutes.

Such publicity as is to be described here can almost be called disinterested publicity, because it is given to and commanded by founders, on certain conditions, not as a return for a cash payment, but as a necessary and inescapable accompaniment of news or service.

One may begin by mentioning the technical lecture or Paper as a first and valuable form of publicity. All foundries are probably familiar with the requests that come to them from time to time, or to members of their technical staff, for Papers to be given to this society or the other on various aspects of founding, or on the particular type of castings in which the foundry specialises. Usually, where circumstances allow, these requests are complied with; but the suggestion in this article is that they should be complied with not merely as an act of courtesy or goodwill, but as a specific arm of the publicity work, and that they should be complied with systematically.

Let us examine more closely what is implied in these lines. First of all, a foundry convinced of the publicity value of this type of activity is not content merely to await invitations to lecture; it goes out and seeks them. The way this is done is as follows. A complete list is got together of all the trade and technical societies that are genuinely significant; and in this connection it must be borne in mind that a foreman's association can often be as important and valuable to the foundry as a national metallurgical society. The foundry then prepares a number of standard lectures, accompanied, where the subject demands it, by accurate slides for lantern use. Thus, one lecture might be on founding methods, another on metallurgical aspects of founding, a third on practical applications or the particular type of castings marketed, and so forth. Each of these lectures is prepared by the appropriate foundry expert; looked over by the publicity manager, who can often suggest interpolations aimed to bring out unobtrusively certain specific advantages possessed by the foundry in connection with the castings under discussion; and duplicated on a suitable machine, so that one's typescript or manuscript does not get lost or dog-eared.

Standard Lectures.

The societies listed are then circularised to the effect that foundry experts are available, if desired, to give lectures before them on such and such subjects. In many instances such a notification brings an immediate crop of invitations to lecture. Now it is obvious that important technicians do not wish to spend their days travelling about lecturing, and it is this that makes the standardisation of the lectures an advantage. Once the lecture has been thoroughly prepared and standardised, the assistant metallurgist, for example, is as capable of giving it and of replying to discussion as the chief, who may be unable to deliver the Paper himself. From the point of view of the Institution, the matter of the Paper is what counts, and, so long as the lecturer can deal adequately with questions and arguments, the main purpose is served.

But where, it may be asked, is the value of this dissipation of energy? The answer is in the publicity obtained. Most of the people who attend technical lectures are themselves technicians or students of technical matters. They are the purchasers or specifiers of the present or the future. There, before them, on the lecture platform, is the representative of a particular foundry. From the quality of his material they gather that *he knows;* he is an expert; they feel greater confidence in the firm that has sent him because of his manifest acquaintance with his subject. The little bits of eulogy of his own firm's work that he cannot quite introduce into his lecture can be thrown out in discussion afterwards, public or private. There is an opportunity to get into touch, direct personal touch, with a whole body of potential users.

But it does not end there. Most of these institutions have their own journals, recording proceedings. Often enough the lectures are reprinted in these, with the discussion, and thence find their way into the technical Press, sometimes of two continents. Local reporters and editors give the proceedings a mention in their newspaper editions. Customers not themselves able, for one reason or another, to attend the lecture, are able to read and digest the views expressed. In short, a lecture before an institution is so much free publicity for the firm that gives it, and it costs no more than the time and labour of its preparation, plus the possible expenses of the lecturer.

Works Visits.

Secondly, as another form of free or disinterested publicity, there is the works visit. Works visits are a familiar enough matter in the affairs of most foundries, and only too often they are looked upon as nuisances. Important officials are called away from their work to escort undesirable citizens—or so they seem—and to explain in non-technical language complicated processes to people who often do not even remotely understand. But here again the fault is in the method rather than the matter. It is because works visits are so seldom properly planned and organised that they are a source of tedium to many visitors and most visited. Nobody wishes his works (in the foundry industry, at all events) to become a sort of Cadbury's or Port Sunlight; but what steps do foundries take to get the type of visit they wish for?

Mostly they wait until approached by some institution that wishes to entertain its members on their annual conference in some city or other; or they leave it to the local chamber of commerce to collect important bodies of folk and show them round. This is all wrong. What is needed is careful organisation to pre-arrange the works visits, and to confine them as far as possible to those that have publicity and sales value.

This is done, first of all, on rather similar lines to the lecturing. Institutions of a valuable character are invited to bring parties of their members; dates and times are specified, and programmes put forward. Engineers or purchasers from overseas lands known to be home on leave or coming home are urged to come to see the foundry. Chambers of commerce and local bodies are advised *in advance* whether or not certain bodies can be welcomed, but the matter does not rest there.

Organising for Publicity.

As important as the prearrangement is the organisation of the visit itself. The first item is the plan. The visitors should be furnished beforehand, individually or through their organisations, with a route card showing the times of their visit, and the places and processes they are going to see. These cards can be quite simply and inexpensively run off on an office printing machine. The next thing is transport. If the visiting organisation has not already made its own arrangements, the firm itself should undertake this, either by hiring corporation or local buses, by sending works cars or such other means as may be available. Someone from the foundry should meet the visitors and bring them to their destination, since it is not without precedent for parties to be delivered at the wrong works or the wrong gate by their unofficial guides. Departments to be visited should be notified long beforehand, and frequently reminded, and a guide from each of them should be told off in advance to join in escorting the party. If any meals or refreshments are being provided, the persons responsible must be advised well in advance, and the place and time settled accurately. A photograph of the party *on arrival* is always appreciated, and as they have not then had time to become dusty and dishevelled, the result will not be too bad, if the photographer has been given warning and is promptly in position at the appointed time. On departure, the members of the party should be given some form of souvenir, usually a printed brochure descriptive of what they have seen. People like to go over with their friends and wives the scenes they have witnessed. Whether the heads of the foundry accompany the visitors or not, a greeting and a farewell from one or other or all of them is always worth while, and creates a good impression.

Here, again, a great deal of valuable publicity is to be gained from these visits, quite apart from the opportunity given of impressing potential customers with the work being done and the methods of doing it. The Institution journals contain detailed accounts (and usually ask for photographs) of the visits made. The local Press will give some space to important visitors. Technical journals regard some of these items as news, especially if new processes are described or new products revealed; hence the advisability of inviting Press representatives to accompany the visitors. Editors are usually discreet, and will omit references to things *not* for publication, if an intimation to this effect is conveyed.

If you wish to be certain that nothing is published that you do not wish to appear, and that every detail is accurate, a good plan is to prepare in advance an account of the visit and the items seen, and hand this over, with photographs, to the Press representatives invited. This saves them a lot of trouble, and brings good results.

Peeling and Chipping of Chromium-Plated Surfaces.—The peeling and chipping of chromium-plated surfaces often are traced to too great a thickness of plate. The plate itself is brittle and will not resist impact or abuse when heavy as well as when light. Chipping and peeling also are noticed more frequently when the parts are subjected to wide temperature variations, probably due to expansion of the part under heat, resulting in fracture of the plate. Nevertheless, chromium has been used safely where such a danger would seem to exist—on diamond-boring bars running in bronze bearings at high speed. These bars were about 30 in. long, had an average diameter of 1½ in. and revolved at 1,500 r.p.m. Due to provision being necessary for fine adjustment on tools in the bar, these bars were costly to make, and plating was resorted to as a salvage medium. The first purposely were plated about 0.010 in. thick. The immediate result was ruined bearings caused by fractured plate. The bars then were refinished to leave 0.001 in. thickness of chromium. They then showed a great increase in life over their initial steel-surface performance.—"Steel."

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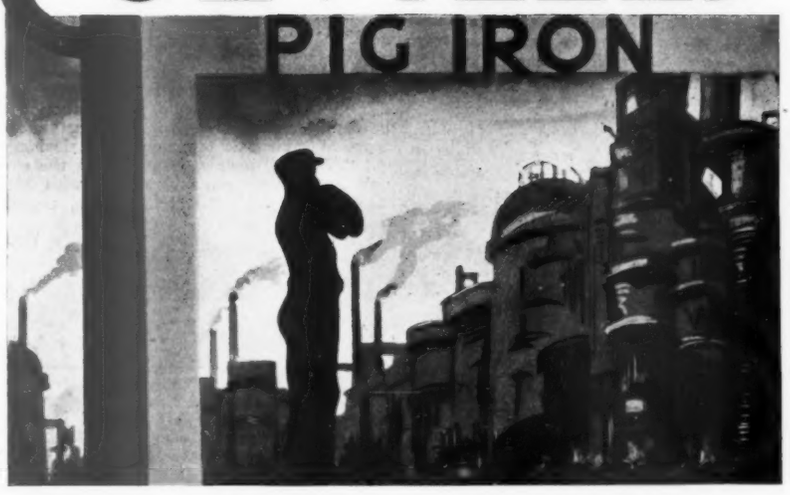

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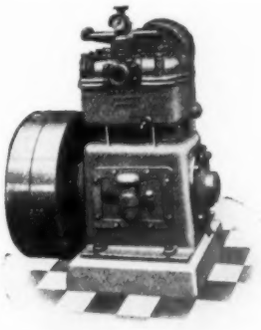

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This Week's News in Brief.

Trade Talk.

The Glamorgan Hematite Iron Ore Company, Limited, Llanharry, are increasing the number of men employed at the mines.

The steamer "Essonite" arrived at Workington recently and sailed on the same tide, after loading 644 tons of pig-iron in three working hours.

At a recent meeting of the Falkirk Dean of Guild Court, Messrs. R. & A. Main, Limited, Gothic Foundry, were granted lining to make a considerable extension to their porcelain enamelling shops.

Messrs. Dorman, Long & Company's Lumpsey ironstone mine reopened last week. Three hundred miners will gradually find employment. It is understood that 50 miners are to be started at the company's Chaloner mine, Guisborough.

The work of preparing the site for the new road bridge over the Firth of Forth at Kincardine has now been begun. It is expected that the new bridge will be completed in about two years, and that the cost will be approximately £250,000.

At the annual staff dinner of Messrs. Thomas L. Hale (Tipton), Limited, it was stated that Mr. W. Edgar Hale started with three employees, and to-day there were 600. Mr. W. E. Hale and his brother, Mr. T. L. Hale, received presentations from the workmen and staff, and the Mayor of Walsall (Councillor J. E. Edge) presented clocks to each of three employees of the firm with long service.

A welcome improvement in trade conditions was the reopening, immediately after Christmas, of the works of the Low Moor Iron Company, Bradford. About 70 men were found work in preparation for the reopening, and others are now being added. In addition to producing the original Low Moor cold-blast iron, mainly used for chilled rolls, production is to be commenced also on Denby semi-cold-blast iron for the heavy-engineering trades.

Messrs. Glenfield & Kennedy, Limited, have booked a number of important orders during the last two or three weeks, including a large number of sluice valves for the Delhi Joint Water Board, the Madras Corporation, the Copenhagen Waterworks, and the Argentine Navy; rotary water meters for the Bangalore Waterworks and clients in South Africa; also a specially-designed pressure-reducing valve for the Mount Bold Reservoir, Adelaide; tilting-disc valves for Shanghai and the Dover train-ferry dock; and a number of drilling valves for the Burmah Oil Company, Limited.

The London & North Eastern Railway Company completed the transfer of the works of the Heatly-Gresham Engineering Company, Limited, from Letchworth to Manchester, when the whole of the foundry equipment, machinery, girders and castings and also household effects, weighing nearly 900 tons, were loaded, conveyed and delivered. Machinery weighing 18 tons per piece was loaded without the use of cranes, and also presses of 40 tons in sections. Special wagons were employed for the movement of several awkward pieces of machinery, and patterns as well as household furniture were carried in containers.

Scottish Branch Annual Dinner.

(*Concluded from page* 373.)

might exist elsewhere the Scottish Branch could be relied upon to perform its part efficiently. He coupled with the toast the name of Mr. Currie.

Mr. J. Currie (Branch-President), referring to the Oliver Stubbs Medal, said that during the last nine years this award had come to Scotland three times. He was specially pleased to note that the three recipients, Mr. Campion, Dr. Donaldson and Mr. Cameron, were present that night. Since its inception the Scottish Branch had through the wise guidance of its executive continued to advance, and at the present time was in a very healthy condition with two sections, one at Falkirk and the other at Edinburgh. A number of members of the branch acted upon the various technical and managing committees of the Institute, worthily upholding Scottish traditions.

During the evening incidental music was provided by a trio, consisting of Messrs. Peter Lamb, violin; Robert Lamb, 'cello, and Mr. William McCluskie, under the direction of Mr. John Gibb, of Coltness Iron Company, and member of the branch council. Songs were rendered at intervals by Messrs. Joseph Leggate and John Gibb.

Mr. Daniel Sharpe, Vice-President of the branch, proposed a vote of thanks to the artistes, and all who had contributed to the success of the function, making special mention of Mr. Bell, the secretary.

The singing of Auld Lang Syne in the usual Scottish fashion brought the function to a conclusion.

Notes from I.B.F. Branches.

Lancashire Branch (Junior Section).—A meeting of the junior section of the Lancashire Branch of the Institute of British Foundrymen was held in the College of Technology on December 16, with Mr. R. A. Jones, of Pendlebury, in the chair. The meeting took the form of a short Paper competition.

The following Papers were submitted by their respective authors:—"Basic Electric Furnace Practice," by Mr. D. Menzies, of Manchester; "Plaster Paris Pattern Making," by Mr. A. Flower, of Manchester; "A Short Survey of the Manufacture of Small Electric Meter Casings," by Mr. A. Boyes, of Manchester; "A Comparison of Cast Iron and Steel," by Mr. A. G. Adams, of Manchester; "The Operation of a Tropenas Converter," by Mr. T. Shaw, of Horwich.

The judges appointed by the Junior Council are:—The President of the Junior Section, Mr. R. A. Jones; the President of the Senior Section, Mr. A. Phillips; Mr. E. Longden, and Mr. J. M. Primrose. Two prizes are provided, one for the winner and one for the runner-up.

Company Meeting.

Presiding at the annual meeting of Messrs. Yarrow & Company, Limited, last week, Sir Harold E. Yarrow, Bt. (chairman and managing director), said competition continued to be very severe, and although there might appear to be rather more activity in shipbuilding within the last few months, the fact remained that the number of new ships likely to be required, even under normal conditions of trade, would be quite inadequate to keep the many shipbuilding yards in the world occupied. British firms, unfortunately, were placed at a further disadvantage due to the subsidies granted by many foreign governments to their own shipyards and shipping. The boiler department had sufficient work in hand to keep busy for several months, and more inquiries were being received for boilers from industrial firms, showing increased interest in the marked economies that could be effected by modernised steam-generating plants.

Merchandise Marks Act, 1926.—The Board of Trade give notice that they have referred to the Standing Committee an application for an Order in Council to require the marking with an indication of origin of imported fittings of iron or steel for wrought-iron or steel pipes and tubes.

Representatives of any interests substantially affected by the application, who desire to be heard in opposition at the public inquiry which will be held later by the Committee, should communicate with the secretary, Mr. E. W. Reardon, at the Board of Trade Offices, Great George Street, London, S.W.1, as early as possible, and in any case not later than January 27, 1934.

Personal.

Mr. Ian Carmichael, welfare superintendent of Clydesdale Steel & Foundry Company, Limited, has resigned from the Lanarkshire County Council, in view of his transfer to Corby, Northamptonshire.

Mr. G. R. Webster, who for the past eight years has held an important position on the technical production staff of the Telegraph Construction & Maintenance Company, Limited, London, the manufacturers of submarine telegraph and telephone cables, and "Telcon" metals, is leaving at the end of the year to take up an appointment with Messrs. J. Stone & Company, Limited, London, engineers and founders.

Obituary.

Mr. George Clay, of Messrs. Clay & Atkinson, engineers and brassfounders, Bradford, died recently, aged 67.

Mr. Tom Craven, of Messrs. Gresham & Craven, Limited, engineers, of Salford, died in London last week. Mr. Craven, who was 83, had been in retirement for some years. The firm was founded by Mr. James Craven, his father. Throughout his long business career Mr. Tom Craven retained an active interest in the firm. He was also for many years a director of Messrs. Beyer, Peacock & Company, Limited, of Manchester, and of the old Cambrian Railway Company.

Company Reports.

Greenwood & Batley, Limited.—Half-yearly dividend on the preference shares.

Whitehead Iron & Steel Company, Limited.—Interim dividend at the rate of 10 per cent. per annum in respect of the half-year ended September 30, 1933.

Millom & Askam Hematite Iron Company, Limited.—The directors have decided to withhold the payment of the preference dividend due on January 1.

New Companies.

"Steelite" Foundry Company, Limited.—Founders, smiths, machinists, etc. Capital £8,100. Directors: O. Sutton, 1, Glendale Avenue, Monkseaton; Heather W. Sutton and W. J. Campbell.

"Campston" Patents Company, Limited.—Founders, smiths, machinists, etc. Capital £100. Directors: O. Sutton, 1, Glendale Avenue, Monkseaton; Heather W. Sutton and W. J. Campbell.

Walter A. Blackburn, Limited.—To take over the business of malleable ironfounders carried on at Phœnix Foundry, Bloxwich, Wallsall, Staffs. Capital £5.000. Subscriber: W. A. Blackburn, Whiw Sill, Haldon Avenue, Teignmouth, Devon.

Catalogue Received.

Wire Screens.—Mining & Industrial Equipment, Limited, 11, Southampton Row, London, W.C.1, have sent us a copy of a brochure of foolscap size dealing with Tyler and Hum-mer screens. These are used in various sections of the foundry industry for screening sands, the idea being that one should have two screens superimposed one above the other. The material remaining on the upper one and that falling through the lower one should be discarded, whilst that remaining on the lower screen should be re-used. It would be preferable to use a dust exhauster above the upper screen if cored worked is being made. We seem to remember an illustration of such a plant, but it is not included in the pamphlet under review.

We were impressed by the Ty-Lab Tester, which nests seven screens and vibrates them by an electric motor, as it might be suitable for a sand-testing laboratory. The firm does supply ordinary nests of screens, and they are illustrated on page 15.

STERLING FOUNDRY SPECIALTIES LTD.
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"STERFLASK, BEDFORD."
.....they play an important part in modern foundry production —— save unnecessary labour, produce accurate castings & reduce your Box Maintenance costs ——
Sterling
SOLID RIBBED ROLLED STEEL
FOUNDRY MOULDING BOXES

Raw Material Markets.

Owing to the holidays, there has been little change in conditions to report during the past week. Good deliveries of pig-iron were made to consumers in the weeks preceding Christmas, and there is every prospect of an active market in the New Year.

Pig-Iron.

MIDDLESBROUGH.—The demand for pig-iron has remained very heavy in this area, and any surplus which accumulated at the furnaces over the holiday will be speedily absorbed. Production is to be expanded at an early date. An additional blast furnace will be started on Cleveland iron at the Skinningrove works in two or three weeks' time. By the end of February it is anticipated that there will be five additional stacks in operation in this area, one producing Cleveland foundry, two steelworks iron and two East Coast hematite. All home sales are governed by the official minimum scale, which for No. 3 Cleveland G.M.B. is 62s. 6d. per ton, delivered Middlesbrough, for No. 1 Cleveland foundry 65s., and for No. 4 foundry and No. 4 forge 61s. 6d. per ton. The delivered prices of No. 3 Cleveland G.M.B. in other areas are :—North-East Coast, 64s. 6d.; Falkirk, 62s. 3d.; and Glasgow, 65s. 3d. per ton, with the usual margins for other grades.

East Coast hematite remains in a strong position. The makers are fully booked, but more business could be done if supplies were available. Merchants are not inclined to sell what supplies they have at the present rates, as they consider a rise imminent. Quotations remain at 62s. 6d. per ton f.o.t. for East Coast mixed numbers, with 6d. per ton premium for No. 1 quality. The export price is about 60s. per ton f.o.b.

LANCASHIRE.—Deliveries of pig-iron have been interfered with less than usual by the holidays this year. In the Manchester district some of the foundries are still idle, but the majority resumed work yesterday. Meanwhile, for delivery to users in the Manchester zone, Staffordshire, Derbyshire and North-East Coast brands of No. 3 iron are all quoted on the basis of 67s. per ton, with Northamptonshire at 65s. 6d., Derbyshire forge at 62s., Scottish foundry at up to 80s., East Coast hematite at about 76s. 6d. and West Coast at 80s. 6d.

MIDLANDS.—The demand for pig-iron in this area, particularly as regards the light-castings trade, was strongly maintained right up to the holidays—an indication of the improving state of the industry. Prices are unchanged at 62s. 6d. per ton for Northants No. 3 and 66s. for Derbyshire, Lincolnshire and North Staffordshire No. 3. These prices are delivered Birmingham and Black Country stations, subject to rebate, and plus 7d. per ton if delivered into consumers' works. Foreign foundry pig-iron is not competitive in the Midlands, and Cleveland No. 3 at 72s. 6d. per ton delivered Black Country is not of any great interest. For Diesel-engine and similar work, where refined iron is used, prices quoted are between £5 15s. and £6 15s., according to analysis. Low-phosphorus iron is from 80s. to 90s., and medium-phosphorus 70s. to 80s., with No. 3 Scottish iron 85s. per ton, delivered Midland stations.

SCOTLAND.—Consumers bought a fair amount of Scottish iron before the holidays, in anticipation of a possible price increase. For the moment, however, quotations remain at 65s. f.o.t. furnaces for No. 3, with 2s. 6d. extra for No. 1. The pressure for English iron so far remains unabated. Cleveland iron is still at 62s. 3d. f.o.t. Falkirk and 65s. 3d. f.o.t. Glasgow.

Coke.

A development in the foundry-coke market has been the making of a slight increase in their quotations by the Welsh producers. In the South Staffordshire area Welsh coke is now quoted at 32s. to 35s. per ton. Other cokes remain unaltered in price in that area, best Durham grades being 36s. to 38s., and Scottish special coke 38s. 6d. to 39s., delivered.

Steel.

The suspension of business over the holidays has precluded any test of the strength of the steel market. Nevertheless, business has recommenced with a most optimistic tone, and the outlook for 1934 is regarded as very favourable. Well-filled order-books insure undiminished production for at least the first quarter of the year, and as regards some materials, increased output will be necessary if the demand is to be fully satisfied. The call for semis is still increasing, and there is little competition from the Continent. The outlook in the finished-steel trade is regarded as much improved, especially since the recent improvement in the shipbuilding industry.

Scrap.

The Cleveland scrap-iron market is generally firmer. Ordinary metal is now up to 51s. and is still in good demand, whilst machinery quality has realised 53s. Light metal is now quoted at 47s. 6d. to 49s. In the Midlands, heavy machinery metal is offered at 52s. 6d. to 55s., heavy pipe and plate scrap at 47s. 6d. to 50s., and clean light scrap at 42s. 6d., all delivered works. In Scotland, heavy machinery scrap, in pieces suitable for foundry cupolas, is quoted at 52s. 6d. to 53s., with ordinary cast to the same specification at 47s. 6d. to 48s. 6d.

Metals.

Copper.—The consumption of copper has lately shown evidence of expansion, both in this country and on the Continent, and the outlook for the metal is regarded as distinctly favourable. The recent recovery in price can be attributed to the rather better conditions reported in America and to the news that a minimum of 9 cents per lb. is to be fixed in that country. It is thought in some quarters that a further rise may be seen in the price of this metal.

The week's prices have been as follow :—

Cash.—Wednesday, £33 3s. 9d. to £33 5s.; Thursday, £32 6s. 3d. to £32 7s. 6d.; Friday, £32 to £32 1s. 3d.; Wednesday, £32 3s. 9d. to £32 5s.

Three Months.—Wednesday, £33 6s. 3d. to £33 7s. 6d.; Thursday, £32 8s. 9d. to £32 10s.; Friday, £32 3s. 9d. to £32 5s.; Wednesday, £32 7s. 6d. to £32 8s. 9d.

Tin.—Trade demand in this country and on the Continent has been quiet, but moderate activity has from time to time been reported in America. The market continues to present a very firm undertone, but without any very definite trend, buyers and sellers alike awaiting the turn of events, particularly in America, and a more definite outlook in the general situation. Fundamental conditions are very much the same as hitherto reported; statistically, the position continues to improve, so that further favourable development in the trading situation, whereby consumption would be stimulated, would in all probability result in advancing prices, state Messrs. Rudolf Wolff.

Daily quotations :—

Cash.—Wednesday, £228 to £228 2s. 6d.; Thursday, £226 17s. 6d. to £227; Friday, £227 12s. 6d. to £227 15s.; Wednesday, £228 to £228 2s. 6d.

Three Months.—Wednesday, £228 2s. 6d. to £228 5s.; Thursday, £226 17s. 6d. to £227; Friday, £227 7s. 6d. to £227 10s.; Wednesday, £227 17s. 6d. to £228.

Spelter.—In accordance with the season of the year, the trade demand in this country has been light, but at the same time offerings have been only moderate, so that the market has maintained its strength. The news with regard to the International Zinc Cartel, referred to before, has also been very satisfactorily received.

Price fluctuations :—

Ordinary. — Wednesday, £15; Thursday, £14 17s. 6d.; Friday, £14 15s.; Wednesday, £14 15s.

Lead.—Quotations in the lead market have recently been remarkably steady, although trade has necessarily been light owing to holiday influences. The undertone remains very firm.

Daily market prices :—

Soft Foreign (Prompt).—Wednesday, £11 7s. 6d.; Thursday, £11 7s. 6d.; Friday, £11 6s. 3d.; Wednesday, £11 5s.

(*Concluded from next column.*)

movement once started will grow, and during the course of the next twelve months the burden of stocks, which has rested so heavily on the producers' shoulders, should be materially lightened.

The Outlook for Copper.

By "Onlooker."

In common with the other non-ferrous metals copper is inclined to suffer from lack of balance, as a result of which extreme fluctuations in the price take place from time to time. In consequence of inflation talk and in anticipation of a 10 cent level under the code, the price in the States was pushed up to 9 cents during the summer months, while on this side London listed electro at £44. The advance to these levels was not justified, but standard warrants were being eagerly bought by speculators, or, in other words, the public was taking a hand in the game, and in consequence the rise was sadly overdone.

When consumption failed to live up to the level set by the speculator there was a revulsion of feeling, and bulls of the metal made haste to get clear with their profits, while the bear faction prepared itself for the fray. Once again the market trend was reversed, and the quotation fell by £12 from the top before sanity returned, and consumers began to buy as if they meant it. With electro at £32 10s. there was something approaching a rush, and everyone realised that the pendulum had swung too far and must be expected to come back with a jerk. This in fact is what has happened, and at the time of writing consumers have already paid £36, while a revival of talk about the code, coupled this time with the suggestion of a minimum price of 9 cents, makes it appear very likely that the rise will go further before a halt is called. Interest in the standard market has revived, and the turnover is now two or three times as great as it was a few weeks ago.

Should the code be adopted it ought to have a steadying effect upon copper values in America, and since London has not yet altogether shaken off the influence of New York it must be assumed that an upward movement in the States will encourage higher prices on this side. Nevertheless it must be remembered that the code is designed to meet those special conditions which obtain across the Atlantic, where the average cost of production is considerably higher than in Africa, Canada and Chile, so that if 9 cents is considered adequate to take care of the U.S.A. mines, the world's cheap producers ought to be perfectly comfortable about marketing their copper well below that figure. This aspect is emphasised because there cannot be any doubt that speculative buying from all parts of the world is converging on London, and may easily result in a rise in the quotation for standard copper, which will be out of proportion to the present economic value of the metal outside the tariff protected boundaries of the United States.

To such an extent has America occupied the centre of the stage in copper affairs over a number of years that there is perhaps a tendency to over-emphasise the importance of American influence, and to consider that anything extraneous to affairs in the States must be impotent to raise or lower the copper quotation. There is at this juncture evidence that world trade is on the up grade, and this cannot fail to be a factor of importance in endeavouring to predict the future course of commodity prices. By every standard of comparison copper must be considered to-day to be still on the bargain counter, and if we are at the beginning of a cycle of rising commodity values then copper ought to benefit very materially. All round economies have, it is true, resulted in a cheapening of production, but following such a period as the year 1932, when the price averaged but little over 5 cents, it would be strange indeed if producers did not use every endeavour to get values on to a more lucrative level.

The dawn of that opportunity for producers of copper seems now to be breaking, for confidence in the fortunes of the metal is returning, and at long last consumers are beginning to show signs of wishing to accumulate stocks somewhat in excess of bare requirements. This

(*Concluded in preceding column.*)

XUM

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EXPERIENCE
FRODAIR
PIG IRON
as used on the
RAILWAYS
for 30 years
BEST
AFTER
TEST
FRODAIR IRON & STEEL CO., LTD.,
FENCHURCH HOUSE, LONDON, E.C.3.

RAW MATERIALS—PRICE LIST.

(Wednesday, December 27, 1933.)

COPPER.

	£	s.	d.
Standard cash	32	3	9
Three months	32	7	6
Electrolytic	35	10	0
Tough	34	0	0
Best selected	34	10	0
Sheets	62	0	0
India	44	10	0
Wire bars	36	5	0
Ingot bars	36	5	0
H.C. wire rods	39	5	0
Off. av. cash, November	30	12	6
Do., 3 mths., November	30	15	3¾
Do., Sttlmnt., November	30	12	6
Do., Electro, November	34	6	4 5/11
Do., B.S., November	33	16	3
Do., wire bars, November	34	14	9 3/11
Solid drawn tubes			10d.
Brazed tubes			10d.
Wire			6½d.

BRASS.

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	8⅜d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7⅝d.
Wire	7⅜d.
Rolled metal	7d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5⅜d.
Do. 4 × 3 Sheets	5¾d.

TIN.

	£	s.	d.
Standard cash	228	0	0
Three months	227	17	6
English	228	10	0
Bars	230	0	0
Straits	232	10	0
Australian (nom.)			—
Eastern	230	10	0
Banca	232	10	0
Off. av. cash, November	226	16	3 13/22
Do., 3 mths., November	226	8	10 4/11
Do., Sttlmt., November	226	16	4 4/11

SPELTER.

	£	s.	d.
Ordinary	14	15	0
Remelted	14	10	0
Hard	12	10	0
Electro 99.9	17	0	0
English	15	7	6
India	14	10	0
Zinc dust	20	0	0
Zinc ashes	3	5	0
Off. aver., November	15	3	11 5/11
Aver. spot, November	15	0	11 13/22

LEAD.

	£	s.	d.
Soft foreign ppt.	11	5	0
Empire	11	10	0
English	12	15	0
Off. average, November	11	13	1 27/44
Average spot, November	11	10	8 19/22

ALUMINIUM.

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	25	10	0
Do., V.M. ex whse.	23	7	6
Rods	28	15	0

ANTIMONY.

	£	s.	d.
English	37 10 0 to 40	0	0
Chinese, ex-whse.	26	10	0
Crude	20	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	9	5	0 to 9 15 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	6 10 0
45/50%	12 10 0
75%	18 2 6
Ferro-vanadium—	
35 50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	5/6 per lb.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£14 10 0
Ferro-tungsten—	
80/85%	2/6 lb.
Tungsten metal powder—	
98/99%	2/9 lb.
Ferro-chrome—	
2/4% car.	32 0 0
4/6% car.	23 0 0
6/8% car.	21 12 6
8/10% car.	21 12 6
Ferro-chrome—	
Max. 2% car.	34 10 0
Max. 1% car.	35 12 6
Max. 0.70% car.	37 10 0
70%, carbon-free	10½d. lb.
Nickel—99.5/100%	£225 to £230
"F" nickel shot	£202 10 0
Ferro-cobalt, 98/99%	5/– lb.
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export (nom.)	£9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ⅛ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/– lb.
Flats, ⅛ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel				2	10	0
Bundled steel and shrngs.	2	2	6 to	2	10	0
Mixed iron and steel	2	5	0 to	2	6	0
Heavy cast iron				2	5	0
Good machinery	2	7	6 to	2	8	6
Cleveland—						
Heavy steel	2	10	0 to	2	14	0
Steel turnings				1	11	6
Cast-iron borings				1	2	0
Heavy forge				2	10	0
W.I. piling scrap				2	5	0
Cast-iron scrap	2	11	0 to	2	13	0
Midlands—						
Light cast-iron scrap	2	2	6 to	2	5	0
Heavy wrought iron				2	15	0
Steel turnings, f.o.r.				1	9	0
Scotland—						
Heavy steel	2	7	6 to	2	10	0
Ordinary cast iron	2	7	6 to	2	8	6
Engineers' turnings				1	17	6
Cast-iron borings				1	17	6
Wrought-iron piling				2	11	0
Heavy machinery				2	12	6

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	26	0	0
Brass	19	10	0
Lead (less usual draft)	10	10	0
Tea lead	7	10	0
Zinc	9	10	0
New aluminium cuttings	70	0	0
Braziery copper	24	0	0
Gunmetal	24	0	0
Hollow pewter	150	0	0
Shaped black pewter	105	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/–
Foundry No. 3	62/6
,, at Falkirk	62/3
,, at Glasgow	65/3
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	63/–
Hematite M/Nos., f.o.t.	62/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	69/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/–
,, No. 3 fdry.	66/–
Northants forge	58/6
,, fdry. No. 3	62/6
,, fdry. No. 1	65/6
Derbyshire forge	62/–
,, fdry. No. 3	66/–
,, fdry. No. 1	69/–
Scotland—	
Foundry No. 1	67/6
,, No. 3	65/–
Hem. M/Nos. d/d	66/–
Sheffield (d/d district)—	
Derby forge	59/6
,, fdry. No. 3	63/6
Lincs forge	59/6
,, fdry. No. 3	63/6
E.C. hematite	76/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/–
Staffs fdry. No. 3	67/–
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	80/–
Clyde, No. 3	80/–
Monkland, No. 3	80/–
Summerlee, No. 3	80/–
Eglinton, No. 3	80/–
Gartsherrie, No. 3	80/–
Shotts, No. 3	80/–

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	0	0 to	9	15	0
Nut and bolt iron	6	17	6 to	7	10	0
Hoops	10	10	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 to	12	0	0
Bolts and nuts, ¾ in. × 4 in.				13	15	0
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	5	0 to	8	10	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ⅜ in. (Untested)	7	12	6 & up.			
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	0	0
Hoops (Staffs)	10	10	0 & up.			
Black sheets, 24g. (4-t. lots)				10	5	0
Galv. cor. shts. (,,)				12	15	0
Galv. flat shts. (,,)				13	5	0
Galv. fencing wire, 8g. plain				14	0	0
Billets, soft	5	10	0 to	5	15	0
Billets, hard	6	17	6 to	7	2	6
Sheet bars	5	0	0 to	5	10	0
Tin bars				5	0	

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	11d.
Sheet to 10 w.g.	12d.
Wire	12d.
Rods	11d.
Tubes	15d.
Castings	13d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	19.26
No. 2 foundry, Valley	17.50
No. 2 foundry, Birm.	18.50
Basic	18.89
Bessemer	19.76
Malleable	19.39
Grey forge	19.39
Ferro-mang. 80%, seaboard	82.00
O.-h. rails, h'y, at mill	36.37½
Billets	26.00
Sheet bars	26.00
Wire rods	36.00
	Cents.
Iron bars, Phila.	1.89
Steel bars	1.75
Tank plates	1.70
Beams, etc.	1.70
Skelp, grooved steel	1.60
Steel hoops	1.85
Sheets, black, No. 24	2.25
Sheets, galv., No. 24	2.85
Wire nails	2.35
Plain wire	2.20
Barbed wire, galv.	2.85
Tinplates, 100-lb. box	$5.25

COKE (at ovens).

Welsh foundry	20/– to 25/–
,, furnace	18/–
Durham foundry	21/– to 25/–
,, furnace	16/–
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	16/6
,,	28×20 ,,	33/–
,,	20×10 ,,	24/– to 24/1½
,,	18¾×14 ,,	17/1½ to 17/3
C.W.	20×14 ,,	15/– to 15/3
,,	28×20 ,,	31/9 to 32/–
,,	20×10 ,,	22/– to 22/3
,,	18¾×14 ,,	15/6 to 15/7½

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0 to	£7	0	0
Bars-hammered, basis	£16	0	0 to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	0	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£30	0	0 to	£31	0	0
Faggot steel	£18	0	0 to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0 to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Dec. 20	..	33	3	9	dec. 1/3
,, 21	..	32	6	3	,, 17/6
,, 22	..	32	0	0	,, 6/3
,, 27	..	32	3	9	inc. 1/3

Electrolytic Copper.

		£	s.	d.	
Dec. 20	..	36	5	0	inc. 5/-
,, 21	..	35	15	0	dec. 10/-
,, 22	..	35	10	0	,, 5/-
,, 27	..	35	10	0	No change

Standard Tin (cash).

		£	s.	d.	
Dec. 20	..	228	0	0	No change
,, 21	..	226	17	6	dec. 22/6
,, 22	..	227	12	6	inc. 15/-
,, 27	..	228	0	0	,, 7/6

Tin (English ingots).

		£	s.	d.	
Dec. 20	..	228	10	0	No change
,, 21	..	227	10	0	dec. 20/-
,, 22	..	228	5	0	inc. 15/-
,, 27	..	228	10	0	,, 5/-

Spelter (ordinary).

		£	s.	d.	
Dec. 20	..	15	0	0	dec. 3/9
,, 21	..	14	17	6	,, 2/6
,, 22	..	14	15	0	,, 2/6
,, 27	..	14	15	0	No change

Spelter (Electro, 99.9 per cent.).

		£	s.	d.	
Dec. 20	..	17	2	6	dec. 5/-
,, 21	..	17	0	0	,, 2/6
,, 22	..	17	0	0	No change
,, 27	..	17	0	0	,, ,,

Zinc Sheets (English).

		£	s.	d.	
Dec. 20	..	25	10	0	No change
,, 21	..	25	10	0	,, ,,
,, 22	..	25	10	0	,, ,,
,, 27	..	25	10	0	,, ,,

Lead (English).

		£	s.	d.	
Dec. 20	..	12	15	0	No change
,, 21	..	12	15	0	,, ,,
,, 22	..	12	15	0	,, ,,
,, 27	..	12	15	0	,, ,,

AVERAGE PRICES OF GALVANISED CORRUGATED SHEETS (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1903	11 5 0	11 5 0	11 5 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 5 0	11 5 0	11 5 0	11 5 0	11 7 1
1904	11 5 0	11 5 0	11 5 0	11 5 0	10 15 0	10 15 0	10 15 0	10 15 0	10 5 0	10 5 0	10 5 0	10 5 0	10 15 0
1905	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	11 0 0	11 5 0	11 15 0	12 0 0	10 15 0
1906	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 12 6	12 12 6	12 15 0	12 15 0	12 15 0	13 5 0	12 12 11½
1907	13 5 0	13 5 0	13 15 0	13 15 0	13 15 0	13 15 0	13 17 6	13 17 6	13 17 6	13 2 6	12 2 6	13 2 6	13 10 10
1908	13 2 6	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 11 0½
1909	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 16 8
1910	11 15 0	12 5 0	12 5 0	11 15 0	11 10 0	11 10 0	11 12 6	11 12 6	11 12 6	11 12 6	11 10 0	11 10 0	11 13 4
1911	11 5 0	11 1 3	10 15 0	10 15 0	10 13 9	10 10 0	10 13 9	11 0 0	11 5 0	11 5 0	11 5 0	11 7 0	10 19 7½
1912	11 10 0	11 10 0	11 10 0	11 15 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 12 6	12 18 0	12 15 0	12 2 11½
1913	12 15 0	12 15 0	12 15 0	12 11 3	11 18 0	11 15 0	11 15 0	11 15 0	11 15 0	11 3 0	11 0 0	11 2 6	11 18 4
1914	11 7 0	11 7 6	11 7 6	11 5 7½	11 2 6	10 15 0	10 15 0	12 17 6	14 2 0	13 7 0	11 15 7	11 2 6	11 16 0
1915	11 10 8½	13 12 6	14 8 9	15 0 6	17 17 6	20 17 6	20 17 6	20 6 3	17 12 6	18 1 0	22 13 9	25 2 0	18 3 4½
1916	26 5 0	27 12 6	28 0 0	28 5 0	29 0 0	29 0 0	28 15 0	28 3 0	28 15 0	28 15 0	28 15 0	28 15 0	28 6 8½
1917	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 0 0	28 0 0	28 0 0	28 11 3
1918	28 5 0	28 15 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	28 13 4
1919	29 0 0	29 0 0	29 0 0	28 0 0	28 10 0	27 7 6	27 5 0	29 3 0	32 0 0	33 0 0	36 10 0	40 8 4	31 5 9½
1920	46 10 0	49 15 0	53 15 0	56 0 0	55 10 0	54 10 0	52 10 0	48 10 0	44 3 4	39 2 6	35 17 6	30 8 0	47 4 3
1921	28 10 0	25 17 6	24 5 0	23 3 4	22 0 0	22 0 0	23 10 0	21 12 6	20 0 0	18 15 0	18 3 9	17 2 0	22 1 7
1922	16 17 6	15 13 9	16 3 0	16 10 0	16 4 4½	15 15 6	15 16 3	16 16 0	16 8 9	16 6 3	17 1 0	17 7 6	16 7 5½
1923	18 3 1½	19 1 11½	19 8 0	19 10 0	19 7 0	19 1 3	18 0 0	18 13 1½	19 0 0	19 3 9	19 2 6	18 19 4½	18 19 2
1924	18 13 6	18 9 4½	18 5 0	17 15 11½	17 3 0	17 19 4½	18 7 6	18 8 1½	18 8 1½	17 19 6	17 11 3	17 10 0	18 0 10½
1925	17 8 6	17 1 6½	16 9 4½	16 12 0	16 9 8½	16 9 4½	16 0 6	16 1 10½	16 5 0	16 7 0	16 12 6	6 15 0	16 11 0½
1926	16 14 4½	16 5 7½	16 0 6	15 11 10½	15 11 3	16 0 0	16 16 0	16 18 9	16 14 0	16 18 9	17 10 0	6 19 0	16 10 0½
1927	16 3 1	15 7 6	15 3 3	15 3 1½	14 14 4½	14 11 6	14 1 10½	14 0 0	13 19 6	13 16 10½	13 13 1½	13 3 9	14 9 10
1928	13 0 0½	13 2 6	13 6 0	13 2 6	13 3 0	13 6 9	13 11 3	13 10 0	13 10 7½	13 12 6	13 11 6	13 10 0	13 8 8½
1929	13 11 0	13 13 1½	13 12 9½	13 10 11½	13 9 3	13 8 9	13 11 6	13 7 6	13 7 6	13 5 6	12 18 9	12 12 9½	13 7 5½
1930	12 5 0	11 15 0	11 19 6	11 18 7	11 18 0	11 17 6	11 17 6	11 17 6	11 16 3	11 12 6	11 8 9	11 5 0	11 15 11½
1931	11 4 0	11 0 0	11 0 0	11 0 0	10 13 9	9 18 9	9 13 0	9 5 3½	8 19 0½	9 16 0	9 8 9	9 4 0½	10 1 10½
1932	9 2 9	9 14 4½	9 16 0	9 13 9	9 12 6	9 12 6	9 11 0	9 4 4½	9 11 3	10 12 6	11 5 0	11 7 0	9 18 7
1933	11 15 0	11 15 0	11 15 0	11 15 0	11 17 6	12 4 0	12 10 0	12 10 0	12 12 6	12 15 0	12 15 0	—	—

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Pneulec Sand Drying Plant, output 1 ton per hour.

Brearley Type Disintegrators.

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Hand and Pneumatic Types.

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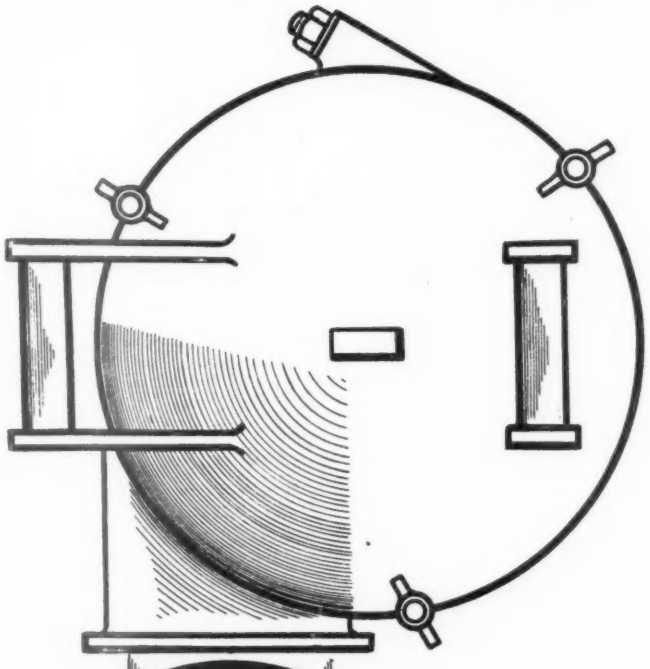

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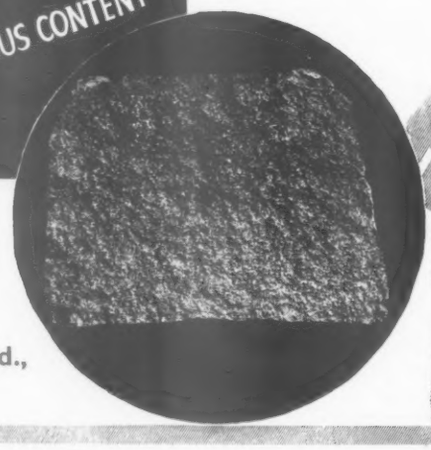

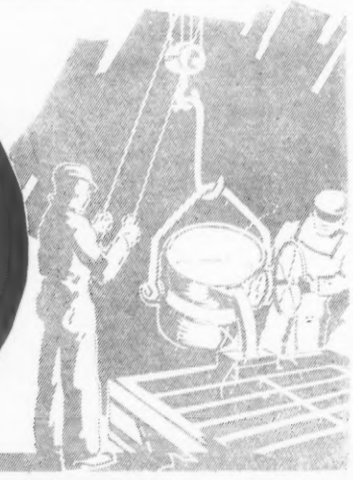

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50% of the sulphur in all blast furnace and mixer metal entering the open hearth furnace can be removed by treatment in the ladle with I.C.I. Sodium Carbonate. The process effects considerable economies. Ladles keep remarkably clean; their maximum carrying capacity is maintained by the elimination of skulls, and damage to their refractories by manual cleaning is avoided.

For every ton of metal leaving the blast furnace or mixer, 20 lbs. of I.C.I. Sodium Carbonate will remove 50% of the sulphur, even when the amount of this impurity is comparatively low.

Typical results:

Sulphur content of Mixer Metal.

Before Treatment.	*After Treatment.*
0.024%	0.012%
0.020%	0.009%
0.030%	0.013%

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The mere use of hot air, as the drying medium, has in itself provided great economies, but hot air supply is by no means the end of the story or the sole source of the resultant economies. Equally as important is the mechanisation introduced by *August's* in the drying process itself. The drying of cores by hot air, for instance, is the cheapest, quickest and most certain, but the elimination of hand labour in stove charging and discharging, and its replacement by mechanical means is just as vital in securing the lowest possible core drying costs.

Of course, the particular type of stove, and method of handling, must obviously be dependent upon the quantity, size, weight and type of cores to be dried per unit time, but from the extensive *August's* range and wide experience, the founder can rely upon securing the most suitable and efficient plant for *any* output of cores. *August's* are not restricted to one type or size of stove, to any one fuel or to any one method of mechanical handling. *August's* have no axe to grind. The method and plant, in their experience the most suitable for your requirements and conditions, is the one which *August's* will propose to you. Just consider the *August's* range :—

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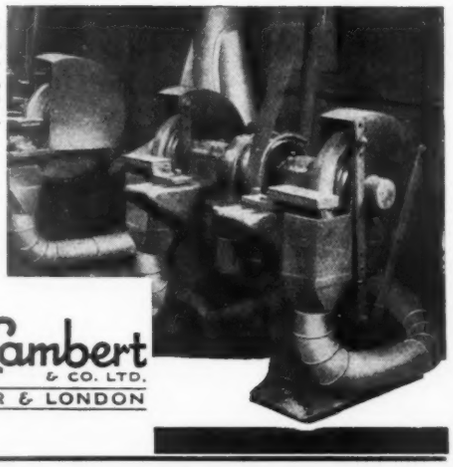

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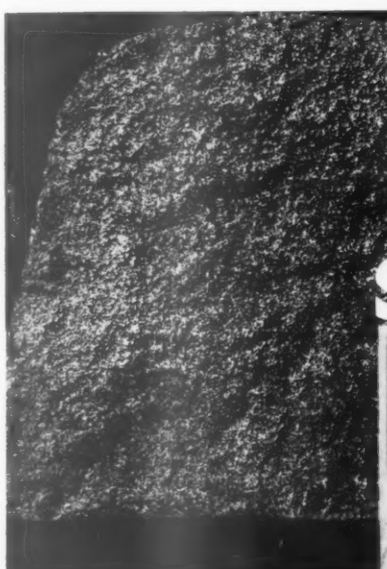

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Sulphur ...	.02	.03	.04	.05	.06	.08	.09	.07	.04	.08
Phos. ...	.50	.50	.50	.50	.50	.40	.40	.32	.20	.20
Mang. ...	1.20	1.15	1.10	1.00	.95	.85	.85	1.08	.80	.80
Graphitic Carbon	3.55	3.40	3.30	3.15	3.10	2.85	2.65	2.80	3.30	2.85
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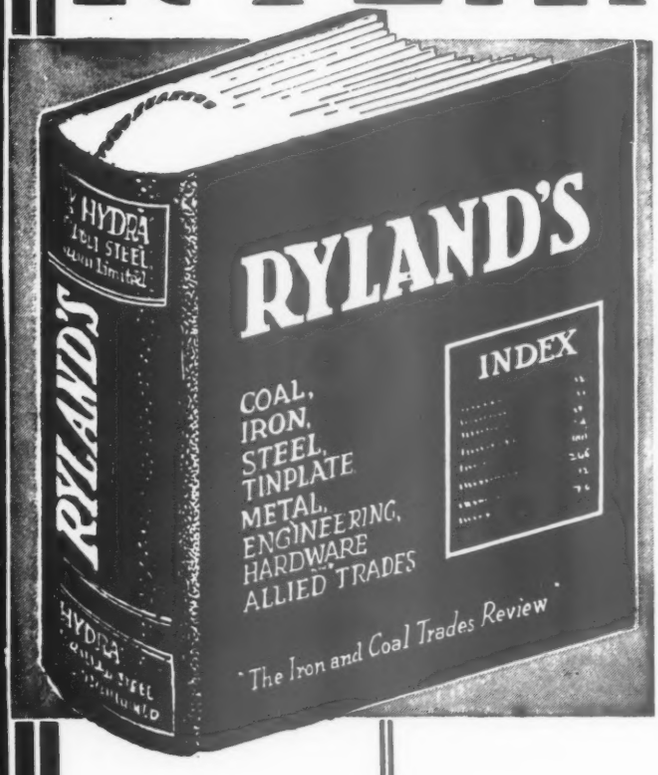

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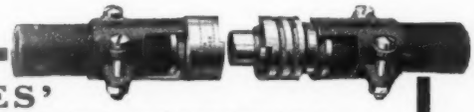

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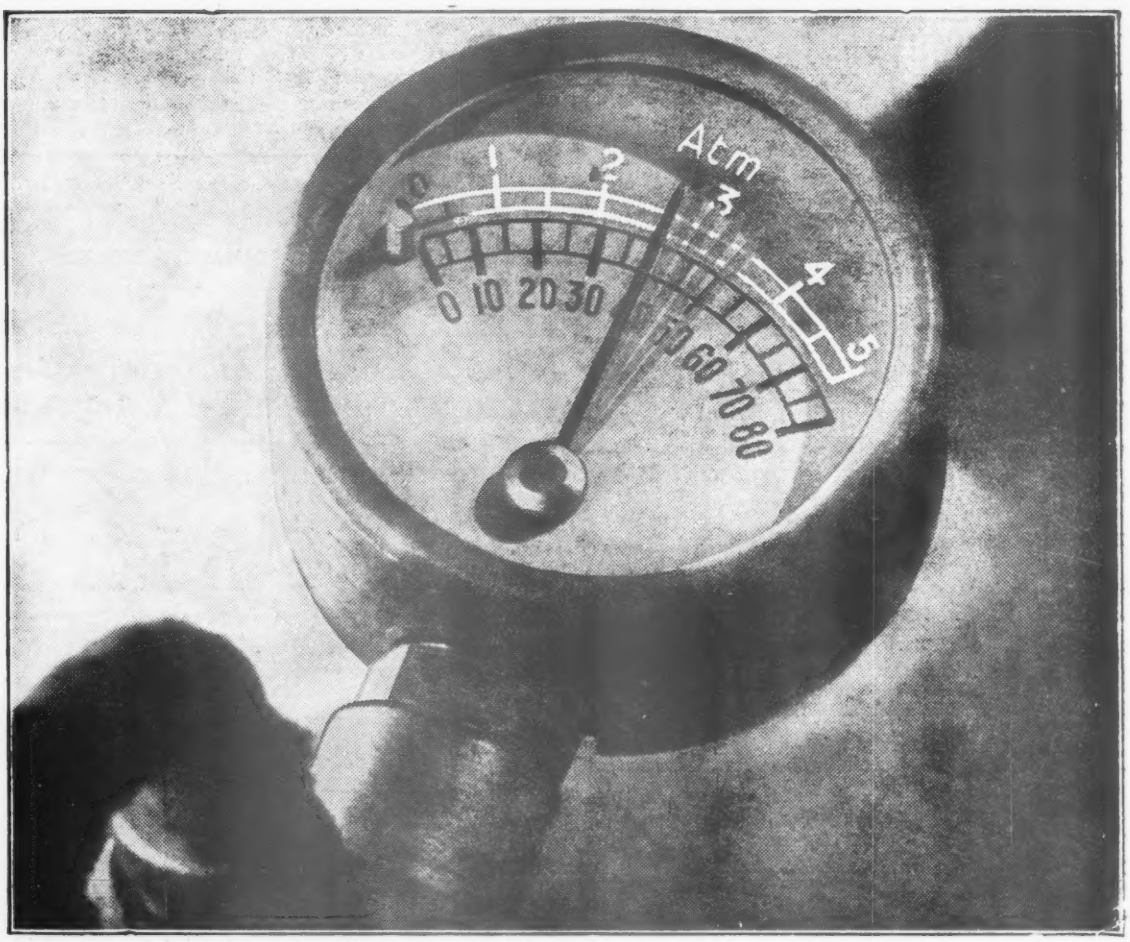

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